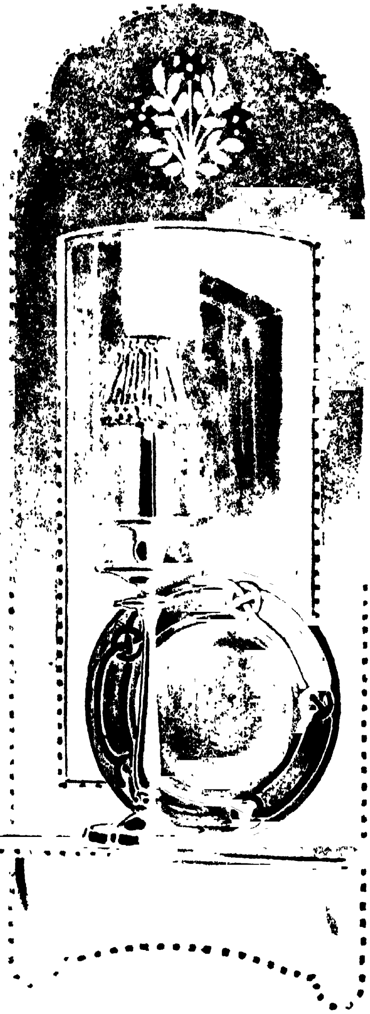
HANDCRAFT
IN WOOD AND METAL



A·Group of·Hand-craft·Models · · ·

Executed in·Metal Wood·and · · · Clay.

HANDCRAFT
IN WOOD AND METAL

A handbook of training in their practical working for Teachers, Students, & Craftsmen

BY JOHN HOOPER, M.B.E.
Late Lecturer and Instructor to the London County Council
Joint Author of "Modern Cabinet Work"
Honours Silver Medallist (City and Guilds of London Institute)
& ALFRED J. SHIRLEY
Technical Instructor and Lecturer on Metal Work to the
London County Council

With over 300 Illustrations from the Authors'
Drawings and from Photographs, including
the Working Drawings of a Progressive Series
of Decorative Objects

Second Edition Revised & Enlarged.

London
B.T. Batsford. Ltd. 94, High Holborn

THIS WORK IS PUBLISHED IN GREAT
BRITAIN BY B. T. BATSFORD, LTD.,
94 HIGH HOLBORN, LONDON, AND IN
THE UNITED STATES OF AMERICA BY THE
MANUAL ARTS PRESS, PEORIA, ILLINOIS

First Published in 1913
Second Edition, 1925

MADE AND PRINTED IN GREAT BRITAIN BY
THE ABERDEEN UNIVERSITY PRESS, ABERDEEN

PREFACE

IN preparing this work the authors have endeavoured to show the possibilities of craftwork as an educational subject, and to briefly indicate its cultural aspects.

One of the prejudices against handcraft or so-called "manual work" has been that it had more value from a physical than an educational or cultural standpoint, with the result that "handcraft" in schools has too frequently been classed as "carpentry".

The authors think that lessons based upon the historical phases of craftwork, particularly in the development of types of construction in furniture and metalwork, and the growth of tools from prehistoric times, together with the study of simple applied art as displayed in historic work, will do much to increase the value of handcraft in schools.

Whilst the work has been prepared primarily for the teacher, the aim has been to render treatment of the subject such as to make the work of value and interest to the craftsman, and a useful guide for the pupil or student. As an aid to class teachers in helping on a technical side in central schools, they hope it will find a place among the books pertaining to craft and general education.

It is hoped further that the work will be regarded as a collection of suggestions and data, rather than an attempt to produce a series of models. The authors believe that at least one aspect of handcraft has been almost entirely neglected in the past, i.e. the artistic side; and, whilst not claiming any special merit for the design of the models dealt with, they have endeavoured to embody some artistic merit in the designs, and have tabooed the meaningless joints and collection of joints which have only a limited mechanical value.

In the early stages, accuracy—whilst being encouraged—should not be too strictly insisted upon. It is a phase which should progress proportionately to the skill of the pupil.

The general impression in the past has been that any attempt a "freehand" curves or decoration in models necessarily means neglect of the mechanical side, but this does not follow according to the authors experience, and they would deplore the acceptance of this idea.

PREFACE.

The main feature of handcraft work after the early stages is individual effort on the part of the pupil, which adds to the interest and value of the subject as a whole.

Much has been said upon "correlation" in handcraft. In well-directed handcraft "correlation" is inevitable. Thinking and doing must perforce be linked together, and when this is done in the class or craft-room it must work toward a better general education.

In elementary handcraft the tendency has always been to depart from traditional methods of construction and processes, but in the authors opinion even the simplest models can be based upon traditional lines, and whether the object of the teacher be vocation or education, due regard to tradition and right methods is essential.

JOHN HOOPER
A. J. SHIRLEY

LONDON,
June, 1913.

NOTE TO SECOND EDITION

SEVERAL illustrations of peasant art in Sweden, Switzerland, etc., have been added by the courtesy of the Editor of "The Studio." These examples illustrate simple decorative treatments of everyday objects, and the study of work of this character is recommended. The fine London museums and the collections in the provinces contain much ancient craftwork in wood, metal and other media, and although the slavish copying of examples has little educational value, it will be appreciated that simple designs based on such examples, combined with the actual examination of old craftwork in museums and other collections, will not only arouse interest in traditional work, but should lead to a keener appreciation and understanding of other subjects in schools. The authors suggest in this connection that visits to museums, etc., by young pupils under the guidance of instructors with a view to the definite study of examples of craftwork, would be of considerable advantage in leading to the formation of taste, and they think that a definite connection between the museums and the schools in this way would naturally lead to a better understanding of the advanced or "fine arts."

J. H.
A. J. S.

June, 1925.

…CTOR OF INDUSTRIES
LIBRARY.

NOTE

MANY of the models and lessons treated in the following pages have been designed and prepared in connection with the authors' duties at the L.C.C. Shoreditch Technical Institute: and they desire to express their thanks to the Principal, Mr. S. Hicks, for permission to reproduce these examples. To Mr. P. A. Wells they wish to extend their gratitude for much kindly help and criticism, also to Mr. A. Rowan of the Handcraft Teachers' Department for assistance in the preparation and revision of MSS. and proofs for the press. Messrs. Nurse & Co. kindly lent the illustration of a grindstone on page 201. Mr. Balfour of the Oxford University Museum has most courteously given permission to illustrate some of the prehistoric tools. Many of the examples of decorative craftwork reproduced in the book are due to the excellent facilities afforded by the authorities of the Victoria and Albert Museum, South Kensington, the source of these examples being noted in the text. In conclusion, the authors desire to place on record their appreciation of their publisher's ungrudging help and consideration during the progress of the work, which materially smoothed its path to the press.

In regard to the illustrations for the New Edition they have to thank for the examples of Swiss peasant art, Monsieur Henri Martin of the Swiss Legation, Herren Orell Füssli, Publishers, Zurich, who issue the German Edition of "Swiss Peasant Art," and "The Studio," London; the illustrations of Scandinavian art have been contributed through the kindness of Dr. G. Upmark, the Northern Museum, Stockholm.

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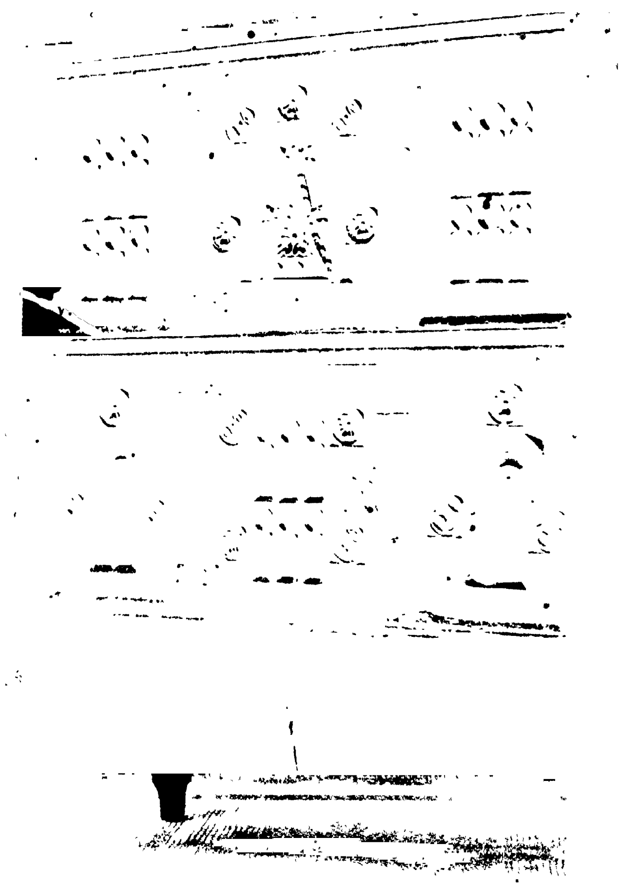


FIG. 5.—English oak livery cupboard, about 1500.

HANDCRAFT

CHAPTER I

HISTORICAL NOTES ON CRAFTWORK

NOTE.—The illustrations are numbered consecutively through each chapter, and the numbering of each chapter is independent of the rest. The pages of collected illustrations have one figure number, the separate diagrams being described as *number* one onwards on each page. Thus references to illustrations are as follows (e.g.)—Ch. XIV, f. 12 (8). Diagrams on the figure under discussion are simply referred to by their own numbers on the illustrations thus (6).

I. WOOD.

> "I do not think that any man but one of the highest genius could do anything in these days without much study of ancient art, and even he would be much hindered if he lacked it."—WILLIAM MORRIS.

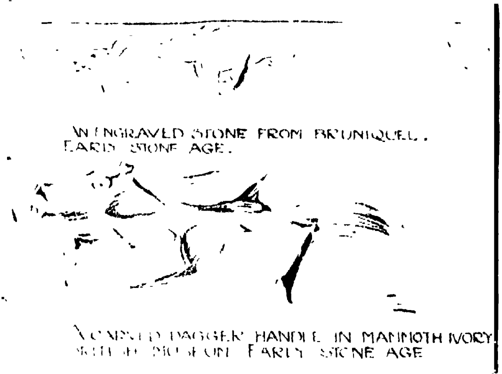
THE purpose of this chapter is to indicate the extreme antiquity of general craftwork, the very beginning of which can fairly be stated to have commenced when prehistoric man fashioned his primitive weapons and implements for defence, attack, and sustenance.

A study of prehistoric examples of craftsmanship in the various national museums will show their manipulative and artistic skill advanced to a considerable degree. Progress in decoration and manipulation proceeded simultaneously, as is evident from existing examples of their production. The Palæolithic—or Early Stone Age—dates back roughly some 7000 years according to authorities on this subject, although with them the dates of periods can only be conjectured. Following this Age or period are the Copper, Bronze, and Iron Ages, so named because of the materials chiefly employed during these periods. Although the general growth of constructive and decorative craftwork did not proceed simultaneously in all countries, authorities agree that stone preceded the use of metal in practically every part of the world, including all parts of Europe, Egypt, China, Japan, and America, the growth of prehistoric work in each of those countries having definite national characteristics, and worthy of close study by students of modern handcraft. Space forbids more than a very rapid survey of this aspect of our subject.

The artistic treatment of animal forms during the Early Stone Age is shown in Fig. 1, an engraved bone or mammoth ivory from Trou des Forges, Bruniquel, France, of exceptional artistic interest. It belongs to the Palæolithic Age and is now in the British Museum. Flint and bone appear to have been the chief media employed, but it should be remembered that the perishable nature of wood has naturally acted against the preservation of objects fashioned from this material.

During the Neolithic or later Stone Age we find more instances of woodworking. Actual examples preserved in collections show that wood was used to some extent for handles of flint knives and axes, generally as a supplementary material to the common use of flint. The Bronze Age marks the introduction of a new material and an increased degree of workmanship and artistic skill, due in some measure to the use of a more sympathetic material, having less limitations than the preceding media.

An interesting feature of this age is the number of bronze celts, which were attached or "hafted" to wooden handles or hafts, and secured by binding with thongs. At the end of this period gold is introduced as a material, fine examples of this work being exhibited in the gold room of the British Museum. Canoes and the lake dwellings of the Swiss also point to an extended use of timber. The Iron Age is especially rich in artistic examples, especially of metal decorated with highly coloured enamels.



AN ENGRAVED STONE FROM BRUNIQUEL. EARLY STONE AGE.

A CARVED DAGGER HANDLE IN MAMMOTH IVORY [illegible] EARLY STONE AGE

FIG. 1.—Examples of animal forms in prehistoric art.

The first historical records on which reliance can be safely placed are those of Ancient Egypt, and they provide a fertile source of study. One of the earliest specimens of Egyptian art in wood is that illustrated in Fig. 2, a wood statue of the so-called Shekh el Beled, found in a tomb at Sakkara. Prof. Flinders Petrie, in his "Art and Crafts of Ancient Egypt," says, "the eyes are excellent in form, but affected by the technical detail of inserting the eyeball of stone and crystal in a copper frame," thus indicating an amount of technical skill combined with artistic appreciation, though the latter is not in accordance with modern ideas. Prof. Flinders Petrie also states that the original figure was covered with a coat of coloured stucco. Of ancient Egyptian furniture there are numerous examples in the British Museum, including workmen's stools, vase stands, a folding stool, and a seat of ebony inlaid with ivory. These display remarkable artistic merit; and show due appreciation of the important factor in modern handicraft, viz. fitness for a given purpose. Technically also these examples are interesting, showing mortise and tenon joints, evidences of the use of glue, and turned work, indicating no small degree of manipulative skill in this branch of handicraft. Two examples are illustrated in Fig. 3. Ebony, acacia, cedar, and sycamore woods were all employed, whilst ivory obtained from the hippopotamus and elephant was utilized for inlaying. Mummy cases, chairs with side arms, caskets, and beds were executed in wood and decorated with inlaying, carving, and painted or stucco decoration. In Greek literature we find considerable evidences of craftwork. Homer's "Odyssey" is especially rich in references, some of which are quoted in later parts of this book. Craftwork was regarded as of importance, as is evident from the following quotation from Book XXIII of the "Odyssey". Odysseus describing the bride bed to Penelope: "Next I sheared off all the light wood of the long leaved olive, and rough hewed the trunk upwards from the root, and smoothed it round with the adze, well and skilfully, and made straight the line thereto and so fashioned it into the bedpost. And I bored it all with the auger. Beginning at this headpost, I wrought at the bedstead until I had finished it, and made it fair with inlaid work of gold, and of silver and of ivory." The Bible also affords us numerous evidences of woodworking, the description of the building of King Solomon's temple being noteworthy, as is also the description of his throne. The ark, according to James Napier in his "Manufacturing Arts in Ancient Times," took twenty-five thousand loads of timber in its construction, and the

FIG. 2.—One of the earliest examples of sculpture in wood.

instructions to Noah, "make thee an ark of gopher wood," etc. indicates the material employed. In Eastern countries, notably India, craftwork is possessed also of ancient traditions; fine carvings, inlay, and other decoration applied to wood and metal have been for centuries produced in abundance. Omitting prehistoric work in England, and much work produced by the Romans here, craftwork in wood and metal does not appear to have made much headway until the sixteenth century, although previous to that date some noteworthy work in stone, chiefly ecclesiastical, had been produced. Wood and metalwork developed almost simultaneously, most early pieces of British craftwork exhibiting a combination of these materials, characterized by crude craftsmanship and of but little artistic merit. Gothic work is the exception, and following that period the English Renaissance, beginning in the reign of Henry VII, saw English woodwork developed through the rich periods of Elizabeth, James, and Cromwell to the early Georgian era which began with William and Mary and Queen Anne. (These and successive periods cannot be better studied than by personal observation in our museums, or from the numerous excellent treatises devoted to historic English furniture and decorative objects.) Great architects such as Inigo Jones, Sir Christopher Wren, the Brothers Adam, and designer-craftsmen including Grinling Gibbons, Sheraton, Chippendale, and Hepplewhite each contributed to the general development of artistic woodwork in England, and nearly all of them have left writings and drawings of their own, which can be studied in our national libraries and museums.

II. METALS AND METAL-WORKING.

While history has always a sentimental value, it has also an indirect, and at the same time through tradition a very direct, bearing on workshop practice. It is besides very interesting, and no apology is necessary for its introduction here. The study of the development of metal-working, and of the many apparently divergent points of view, adds interest to the story of the origin of many processes common to the jeweller and the decorative metal-worker. Only practical workers in each craft can properly appreciate the wide gap that separates them, but many operations are common to all branches dealing with metal. Filing, drilling, turning, hammering, the use of chisels and punches, etc., are as essential to the jeweller as to the decorative or architectural metal-worker, to the watchmaker as to the shipbuilder. A student capable of performing these operations efficiently and so possessing that proficiency which places him in the class of "skilled" labourers has the chance of entering any industry in which metal plays a part. The knowledge of metal-working, as the many specimens in our museums show, dates back to very early historic times; according to various authorities probably as far back as 4500 B.C., or even earlier.

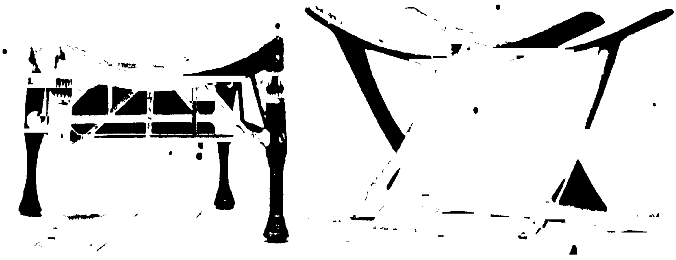
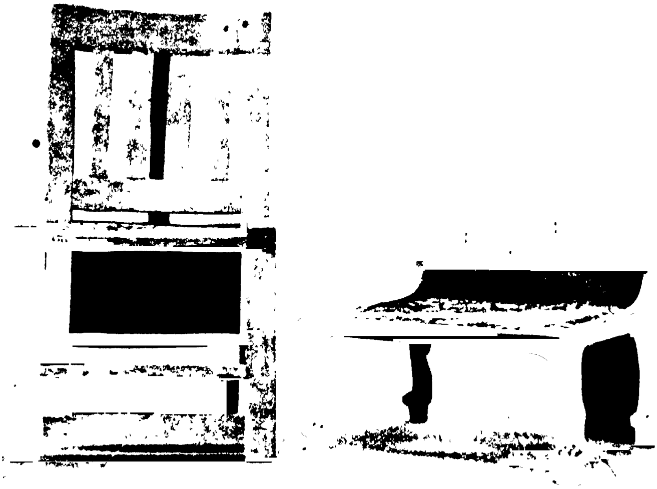


Fig. 3.—Ancient Egyptian stools, one with hide seat, made of inlaid wood



4—Early Egyptian chair and settle, British Museum, showing mortise and tenon joints.

Copper and Gold.—Copper appears to be the first metal generally known and used, although there are evidences that gold was in use in Egypt in 5400 B.C., but the beginning of the uses of metals is known as the Age of Copper.

Copper Age.—How copper was first discovered can only be conjectured, but it was evidently known as a malleable stone, and beaten into shape by stone hammers or pounders.

An inspection of the implement now in the Pitt-Rivers collection at Oxford proves this. It was made from a piece of copper ore, and has, as far as one can judge, not been smelted, but it is evidence of the appreciation and use of metal by a race of people living in the Stone Age.

Following this the search for metals would naturally be developed by slow stages; the uses and methods of shaping this new material would increase until the time arrived when metals could be extracted from their ores, and the art of metallurgy be evolved. The discovery of the various metals marks one of the greatest steps in advancement made by the human race, but it is obvious that all the people in the world would not be equally acquainted with these discoveries at the same time. Nevertheless, the efforts of the early workers who made such advances possible deserve attention.

Bronze Age.—During the later part of the time known as the "Copper Age," gold, silver, copper, and tin seem to have been in general use, and this brings us to the period known as the "Bronze Age," which lasted roughly about a thousand years.

During this time the works in metal are remarkable for their excellence, being suitable for their purpose, beautiful in design, and skilfully executed. Many objects were cast as well as wrought, and many pieces were made combining the two processes, as for example, a vase with a beaten body and cast handles which can be seen in the bronze room in the British Museum. The bronze mirrors of the Greeks are artistic examples of skill. Statues of large size were not cast in one piece, but were made by shaping or embossing plates of metal and nailing them on to a wooden core, casting the hands and feet or other small portions separately, then attaching them by cramps and nails.

The face and hands were often carved from ivory and attached in the same way. Statues made in this way, plated with sheet gold and portions of carved ivory added, were known as Chryselephantine work.

Phidias, the sculptor of the Parthenon, was specially famous for statues of this kind.

Metals of many kinds were early very plentiful, and the following verses taken from Homer's "Odyssey," which is supposed to have been written about eleven hundred years before our era, point to a high degree of skill among metal-workers.

The verses refer to the Palace of Alcinous:—

> Meanwhile Ulysses at the palace waits
> There stops, and anxious with his soul debates,
> Fixed in amaze before the royal gates.

> The front appeared with radiant splendid gay,
> Bright as the lamp of night or orb of day.
> The walls were massy brass; the cornice high,
> Blue metals crowned, in colours of the sky;
> Rich plates of gold the folding doors encase,
> The pillars silver, on a brazen base;
> Silver the lintels deep projecting o'er,
> And gold the ringlets that command the door;
> Two rows of stately dogs on either hand,
> In sculptured gold and laboured silver stand;
> These Vulcan formed with art divine, to wait
> Immortal guardians at Alcinous' gate.

The description of the arms and shield made by Vulcan for Achilles is full of names of metals and processes.

Among the many objects of bronze in the British Museum are some finely modelled handles with iron cores, a bronze belt-plate inlaid with iron, a bronze handle inlaid with silver, some pale bronze mounts probably from a wooden chest and of very thin material embossed with many kinds of fantastic animals, some simple borderings and bosses mainly worked from the back and in low relief; all these objects are dated about 600 to 400 B.C., and can be seen in the bronze room

The remains of the bronze gates of Shalmaneser II, which are in the basement of the British Museum, are quite an object lesson on the teaching of history by pictorial means carried out in repoussé work on bronze, and these date back to 824 B.C.

There are also some examples of work in wood, bronze, ivory, bone, marble, and alabaster that have been turned in a lathe and are dated about 400-300 B.C., all in the room of Greek and Roman life at the same museum; some enamelled bronze ornaments and many vases, figures, etc., which were cast by the lost wax process, and have never been surpassed for beauty of form or executive ability.

Iron Age.—Iron was now gradually coming into use, but it did not displace bronze to any extent, so that the early "Iron Age" overlapped the later "Bronze Age" in the same way as with the Stone, Copper, and Bronze Ages.

Iron was used largely during the later period of Greek history for strengthening objects, such as bronze castings, handles of bronze shields, and as cramps in buildings, in the partial construction of ships, chariots, and agricultural implements; in fact it was put to much the same uses as at the present day.

Iron was also known to have been in use in Assyria about the ninth century B.C. and in India even earlier. The celebrated wootz, a species of iron and the material from which the famous Damascus swords were made, is of very great antiquity. In these early ages its rarity made iron of great value, and in accounts of the battles of the Egyptians, mention is made of its being taken as spoils of war; it was in long, wedge-shaped pieces with holes through to facilitate transport. Uzziah is spoken of in the Bible (2 Chron. XXVI. 14) as making shields, spears, helmets, and habergeons (coats of mail or breastplates). Also in Genesis (IV. 22) we read of Tubal-cain the son of Lamech and Zillah, who was an instructor in brass and iron; "brass was probably bronze of a light brown or yellow colour; the metal now called brass was not then known".

Tubal-cain was probably the mythological God known to Homer as Vulcan. There are many references to metals and metal-working in the Old Testament of the Bible, and these portions were written at least as early as 155 B.C.

Lead and Zinc.—At the beginning of the Christian era lead was used largely by the Romans, and zinc first appears in Roman alloys, but it was also known as calamine to the Greeks who used it in the manufacture of brass by simply fusing the calamine with copper. It was not until about A.D. 1720 that zinc was procured in a metallic state by J. Henkle, a German chemist

Steel.—Steel of some kind was also known and used, being obtained from wootz. As it contained a large percentage of carbon it was very difficult to work. Gold, silver, and bronze were used largely for decorative purposes, and silver was known to the alchemists as luna In their writings it was represented by the figure of a crescent moon.

The Gauls were very skilful in the manipulation of metals, but the industry was only carried on by "Freemen," and when they died the implements of their craft were often buried with them The skill of the Britons was evidently as great as that of the Gauls, and if we examine the objects in the cases Nos. 51-60 in the central saloon of the British Museum, which were made between the years 250 B.C. and the third century A.D., we can realize the degree of excellence craftsmanship had reached Byzantium, or Constantinople as it is now called, was noted for its artistic metal-work.

Enamel.—Enamelling on metal is of very ancient origin, and is said to have been first practised by the early Egyptians Many articles decorated in this manner have been found in Britain, in tombs and what are known as chariot burials, for with the warrior were often buried his chariot, horse trappings, weapons, jewellery, and some vessels of pottery. The work done in Britain at this period by the Gauls or Kelts, known as Keltic work, may be recognized by its graceful flowing curves, rounded surfaces, and "interlacing," as well as by a form of scroll believed to have been derived from the palmette of the Greeks.

Second and Third Centuries A.D.—Copper mines were worked by the Romans in Britain during the second and third centuries A.D., when they made water pipes and coffins from lead often richly cast in relief, and used iron grilles or cancelli in their churches to separate the choir from the body of the church.

Fourth Century A D—In the British Museum there are some cakes or ingots of pewter stamped with the early Christian symbol of the fourth century, also many lamps of bronze with the symbols worked into the design. These were used for lighting the Catacombs, and there are some finger rings of bronze gilt of the same period.

During the reign of Constantine altars were made for use in the many churches then being built. They were made of wood covered with silver plates elaborately worked in relief.

Fifth and Sixth Centuries A.D.—Silver spoons inlaid with niello were used during the fifth century, and Byzantine weights of bronze, with their denominations inlaid with silver, were in use during the sixth century. Dagobert King of the Franks possessed a throne of gilt bronze 628-638, a copy of which is now in the Victoria and Albert Museum.

Eighth and Ninth Centuries A.D.—Inlaying of gold with niello was characteristic of the eighth and ninth centuries, and during the tenth century cloisonné enamelling on gold reached a high degree of excellence.

Tenth and Eleventh Centuries A D.—The tenth and eleventh centuries were the great age of bronze founding, and many of the doors for various cathedrals were made about this time in Constantinople, and exported to various countries. Some were inlaid with silver or niello. Dunstan, Archbishop of Canterbury, 925-988, was an English metal-worker of great skill. It is interesting to note that the sculptors were usually their own founders. Theophilus wrote "Diversarum Artium Schedula" in the early part of the eleventh century.

Twelfth Century A D.—The Pala d' Ora or altar front at St. Mark's Cathedral in Venice was made in the above city during the twelfth century, and is of gold and silver plate, embossed, enamelled, and encrusted with precious stones. A fine example of English craftsmanship where metal is used to special advantage is the beautiful monument to Queen Eleanor in Westminster Abbey, made by Thomas of Leighton Buzzard in 1294. It consists of a finely modelled bronze figure, with a wrought-iron cresting above, the cresting being an early example of decorative punch-work. It was during the twelfth century that machines, some of which were worked by water-power, were first used, and there are still in existence drawings of drilling, sawing, and stamping machines, screw-cutting lathes, and many jigs, that were drawn by Leonardo da Vinci, the Italian craftsman of the fifteenth century.

Fifteenth and Sixteenth Centuries A.D.—Cast Iron.—Between the twelfth and sixteenth centuries Spain produced some exceedingly rich ironwork in the form of *rejas* or screens; but very little decorative ironwork was done in England owing to the scarcity of skilled smiths. About the fourteenth century cast iron came into use, and was smelted with charcoal in Sussex, a large quantity of cast iron being produced in that county.

Seventeenth and Eighteenth Centuries.—Wood becoming scarce, owing to being used (in the form of charcoal) for the production of cast iron, an Act of Parliament was passed during the reign of Elizabeth limiting the erection of furnaces and the use of wood above a certain size for this purpose; consequently the production decreased until the end of the seventeenth century, when the use of pit, or sea coal as it was called, became more general. Even then the quantity produced was very small, and it was not until the method of making coke from coal was invented, about the middle of the eighteenth century, by Abraham Darby, that the commencement of the manufacture of cast iron on a large scale began. The art of tinning iron plate was introduced from Germany by Andrew Yarrenton.

Cast Steel.—It was during this century that a method of making cast steel of a uniform texture was invented by Mr. Huntsman of Sheffield in 1770, and the process was soon in use in various parts of England for the manufacture of steel for cutting tools. Previous to this many cutting tools were imported from the Continent.

Lead.—Lead has been largely in use since the twelfth century for roofs, spires, statues, fonts, gargoyles, cisterns, etc., but to realize the highest possibilities of lead as a decorative as well as a utilitarian medium many towns in France should be visited, where this material has been utilized to a greater extent than in other countries. In some instances lead was decorated by applying a pattern in pure tin, which because of its brilliancy forms an agreeable contrast with the dull lead, and it is not affected by the weather

Nineteenth Century.—The commencement of the nineteenth century was remarkable for the great number of inventions in connexion with metals, but that of H. Bessemer, afterwards Sir H. Bessemer, for producing steel from cast iron by means of the converter invented by himself was the most notable, and at the present time steel made by his process is largely superseding wrought iron

Aluminium.—The discovery by Wohler, a German chemist, in 1828 of aluminium has had far-reaching results, although it is only of late years that this metal has been usefully applied. This is due largely to the improvement in electric furnaces, consequent increased production, and lower working costs.

CHAPTER II

FIRST YEAR MODELS (WOOD)

RULER, FLOWER-STICK, AND KEY RACK (Fig 1).

Object.—Models designed chiefly to introduce exercises in planing and sawing.

The Process.—Round Ruler.—For class work, one piece of wood 12 × 7/8 in. square should be issued to each student. A finely set jack plane should be used for the planing process.

1. Plane up face side and edge. 1a. Pencil face marks on material (straight edge to be employed for testing the above planing).

2. Set marking gauge, and gauge the material for width and thickness.

3. Set out octagon on each end, as per diagram (second step).

4. Plane to octagonal shape (see diagram, second stage).

5. With smoothing plane complete the planing to circular section.

6. Finish with glass paper and saw off ends to finished length.

Flower Stick.—1. Plane to width and thickness one piece yellow deal, 15 × 3/4 × 1/4 in.

2. Set out pointed end, also semicircular top.

3. Saw bottom and corners off top, compare latter by paring

4. Execute notches by cutting with firmer chisel.

Key Rack.—1. Prepare one piece of American whitewood, 10½ × 2¼ × ½ in. = 26 × 6 × 1·2 cm.

2. Plane up face, side, and edge. 2a. Plane and gauge to width and thickness.

3. Mark out the semicircular ends. 3a. Cut same with dovetail saw (see Fig. 1).

4. Pare down to lines with firmer chisel. 4a. Prepare a specimen of chamfering.

5. Set out and execute chamfering on key rack with file.

Note.—In the second and third examples dealt with above, chamfering is employed as the simplest kind of ornament, and permits of individual effort in designing same. For class work an extra piece of wood can be issued and the pupils encouraged to suggest treatments, limiting them to the use of a file and small chisel. A demonstration showing one or two different types should precede their efforts. The hooks can be placed vertically as shown or horizontal for large keys, when the rack is, of course, also fixed in a horizontal position.

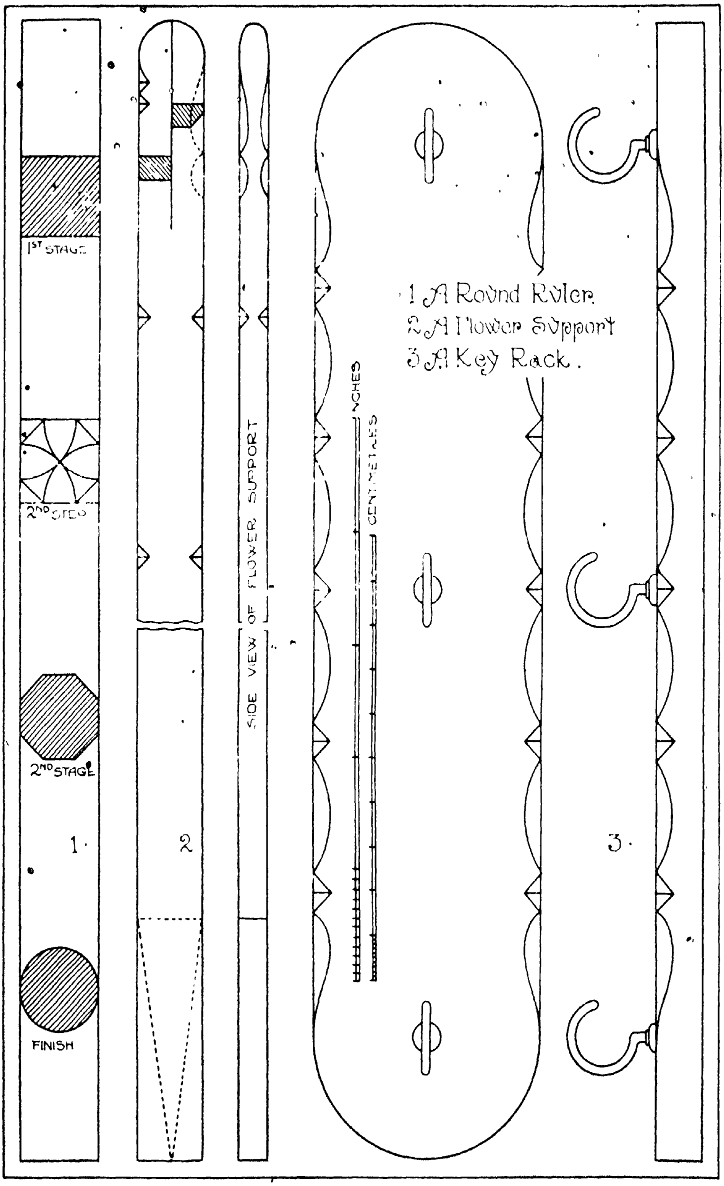

1ST STAGE
2ND STEP
2ND STAGE
FINISH
1·
2
3·
SIDE VIEW OF FLOWER SUPPORT
INCHES
CENTIMETRES
1 A Round Ruler.
2 A Flower Support
3 A Key Rack.

FIG. 1.

A HALF-LAPPED FRAME (Figs. 2, 3, and 4).

Object.—To illustrate the application of a previously constructed joint, i.e. half-lapped joint, to a simple woodworking model. The decoration provides an opportunity for tasteful treatment, and can be of various kinds, viz. gouged, chiselled, inlaid, or stencilled.

The Joint should be made first as an exercise, the procedure for which is as follows:—

1 Plane up one piece American whitewood, 12½ × 2¼ × ⅞ in. = 31·5 × 5·7 × 2·2 cm.

2. Mark face edge, shoot same, gauge and plane to width and thickness.

3. Pencil cross centre line in wood. Saw across.

4. Fix one piece in stops, mark width of the other piece at centre square lines across with marking knife. Repeat with second piece.

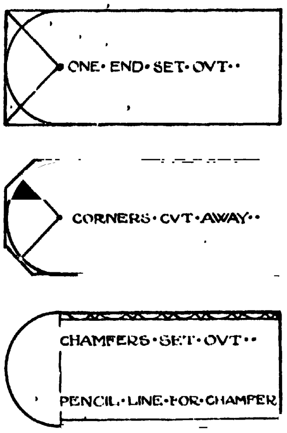


FIG. 2.

5. Square lines on edges, and gauge half-thickness on edges (gauge lines must be made from face side).

6. Cut lines with dovetail saw, and remove waste of each piece.

The Frame.—1. Cut out 4 pieces of American whitewood, 12½ × 1¾ × ⅞ in. = 31·5 × 4·5 × 2·2 cm.

2. Plane up face, side, and edge of each piece.

3. Gauge and plane up all pieces to width and thickness.

4. Fix all pieces in bench stop. Set out lines (A, B, C, D, E, F, Fig. 4) on edges with marking knife

5. Separate pieces. Square lines on two pieces on face side. Square lines on two pieces on back side.

6. Gauge half-thickness on edges for joints from face side.

7. Cut inside line with dovetail saw, remove waste with firmer chisel.

8. Fit together and glue up. When dry level off on both sides.

9. Mark rebate on inside of frame on back, cut same with chisel.

10. Proceed with decorative work (see alternate treatments on opposite page).

The Decoration must at such an early stage be easy of execution. The first kind shown is single gouge cuts on the edge of the frame; this is best executed by holding the gouge in position with the left hand, striking

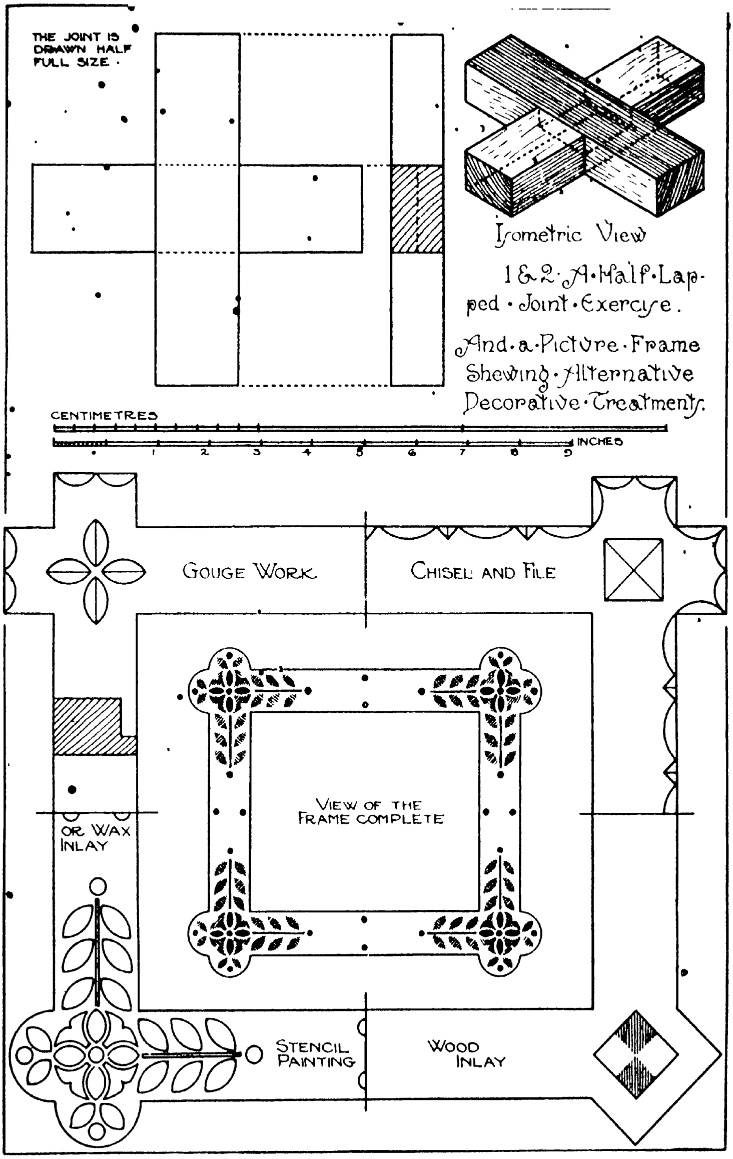

THE JOINT IS DRAWN HALF FULL SIZE ·
Iſometric View
1 & 2 · A · Half · Lapped · Joint · Exerciſe.
And · a · Picture · Frame Shewing · Alternative Decorative · Treatmentſ.
CENTIMETRES
INCHES
0 1 2 3 4 5 6 7 8 9
GOUGE WORK
CHISEL AND FILE
OR WAX INLAY
VIEW OF THE FRAME COMPLETE
STENCIL PAINTING
WOOD INLAY

FIG. 3.

it smartly with the palm of the right hand. Eight cuts are then made in each corner to form the device shown.

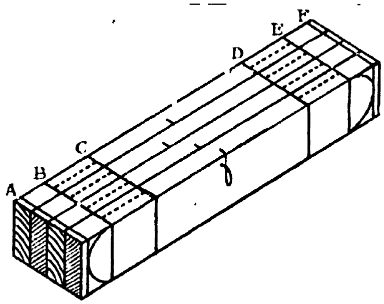


FIG. 4.

The second treatment shown is executed on the edges with gouge and chisel; the corners have a simple recessed device.

The third treatment illustrates a stencilled pattern, which can be executed by drawing the design on paper, cutting the required portions away by means of gouge cuts (for stencilling refer also to bottom of this page).

The fourth treatment consists of two differently coloured woods arranged our in a square. These should be cut from ⅛ in. wood and glued—like mosaic—into the groundwork

The Outlines of the third and fourth examples vary, these should be set out geometrically and finished by paring with a firmer chisel.

WATCH STAND (Fig. 5).

Object.—A model to introduce simple sawing, planing, chiselling, and filing (if curve of back is considered undesirable a straight line can be substituted), also as an exercise in stencilling.

Material.—	*English.*	*Metric.*
1 piece American whitewood,	8¼ × 3⅝ × ½ in.	20·3 × 9·1 × 1 cm.
1 piece „ „	3¾ × 2¾ × ½ in.	9·5 × 7 × 1 cm

The Process.—1. Saw out and *smooth* up material as above.

2. Plane one edge of front, gauge, and plane to width.

3. Mark out semicircular head of front piece.

4. Mark bevel at bottom, cut same with dovetail saw.

5. Set out the support as per Fig 5.

6 Cut head to shape, removing corners with saw; pare away to line with firmer chisel.

7. Cut *straight* back with dovetail saw, finish bottom with gouge.

8. Nail together, holding back in bench vice.

The Decoration, as illustrated, is simple stencilling; the design should be executed on stiff cartridge paper, then cut out with a sharp penknife. The paper is then placed upon the front and held perfectly flat whilst the colour is dabbed upon it with a brush.

Notes.—For class work, simple vee tooling could be substituted for the stencilled design. Painting the whole stand would improve the model; dark green with white or red stencilling are suitable treatments.

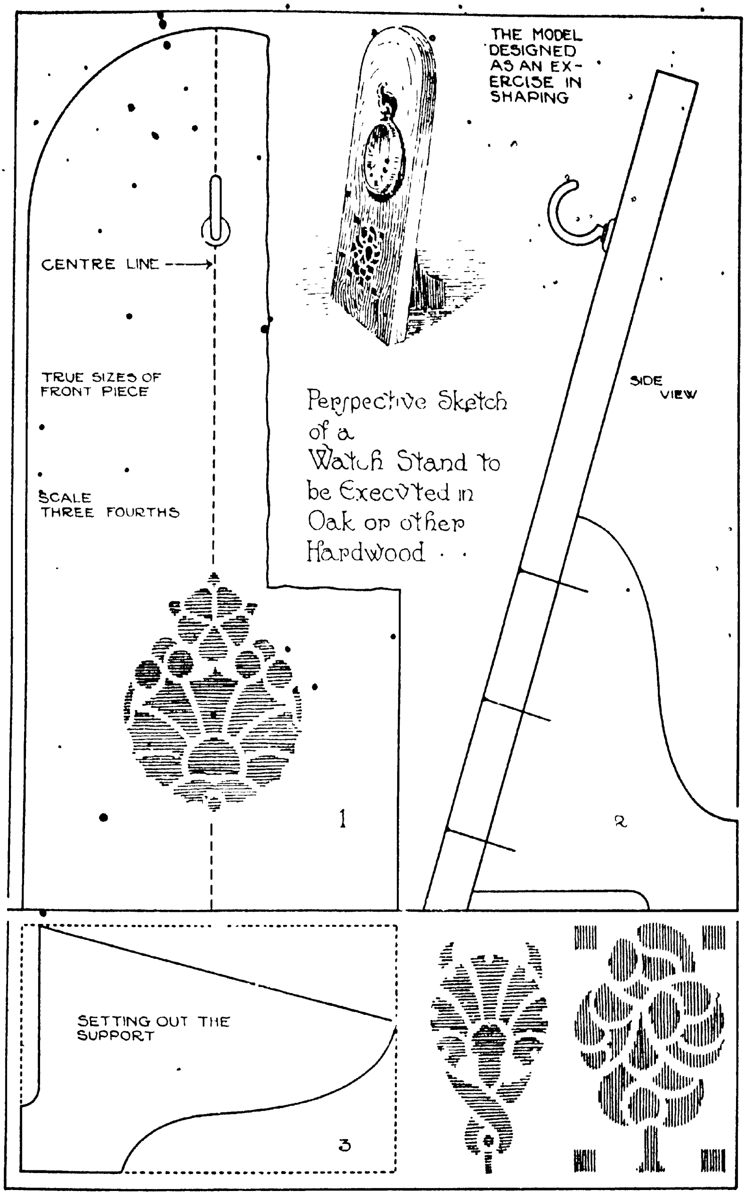

CENTRE LINE
TRUE SIZES OF FRONT PIECE
SCALE THREE FOURTHS
1
THE MODEL DESIGNED AS AN EXERCISE IN SHAPING
Perspective Sketch of a Watch Stand to be Executed in Oak or other Hardwood
SIDE VIEW
2
SETTING OUT THE SUPPORT
3

Fig 5.

A simple geometrical arrangement of spots is also effective; this could be done by boring $\frac{3}{16}$ in. holes about ⅛ in. deep, filling in with coloured wax. (This process is further described on pp. 148, 150.)

PIN AND PEN TRAYS (Fig. 6).

Note.—Nos. 1 and 2, and the perspective sketch on p. 17, illustrate a pen tray, to be executed in American whitewood, and designed in order to introduce sawing, planing, and gouging. No. 3 is the sectional view of a more advanced type, involving the addition of bevelling and a thin moulded base. A cavetto or hollow moulding is a suitable alternative detail for this model. No. 4 is a further development of the above types. Mahogany is suggested for the pen tray proper with ebony feet. A mosaic edging should be worked round the top edges, which is further illustrated and described on p. 146. Satinwood and ebony is a suitable colour combination when mahogany is used for the groundwork. Nos. 5 and 6 illustrate an alternative model for the first year, introducing processes similar to the first example. The further development of this type could proceed upon the lines indicated above in connexion with the pen tray.

Material required for the four models (cutting sizes) :—

	English.	*Metric.*
Nos. 1 and 2 :		
1 piece American whitewood,	10½ × 2½ × ⅞ in.	26·6 × 6·4 × 2·25 cm.
No. 3 :		
1 piece American whitewood,	10½ × 2½ × ⅞ in.	26·6 × 6·4 × 2·25 cm.
1 piece ,, ,,	11 × 2⅞ × ¼ in.	28 × 7·3 × ·6 cm.
No. 4 :		
1 piece American whitewood	4½ × 3¼ × ⅞ in.	11·4 × 8·2 × 2·25 cm.
Nos. 5 and 6 :		
1 piece Cuba mahogany	10½ × 2½ × ⅞ in.	26·6 × 6·4 × 2·25 cm.
1 piece Ebony	4½ × 1¼ × ¼ in.	11·4 × 3·2 × ·6 cm.

The Process (for pen tray. Nos. 1 and 2).

1. Saw out, and plane material to finished thickness, length, and width.
2. Square across pencil lines corresponding to semicircle centres.
3. Describe the semicircles as shown in No. 1.
4. Prepare a ⅛ in. cardboard templet as shown in No. 2.
5. Gouge away the centre part, testing frequently with templet.
6. Finish inside with glass paper, plane and finish the round edges.

Process (for pin tray. Nos. 5 and 6).

1. Saw out, and plane material to finished thickness, length, and width.
2. Draw centre lines on face side, mark axes of ellipse.
3. Prepare a paper trammel and describe ellipse.
4. Gouge away the inside part and finish with glass paper.
5. Round edges and finish.

The use of glass paper in connexion with the above models may in the first year be considered undesirable and omitted.

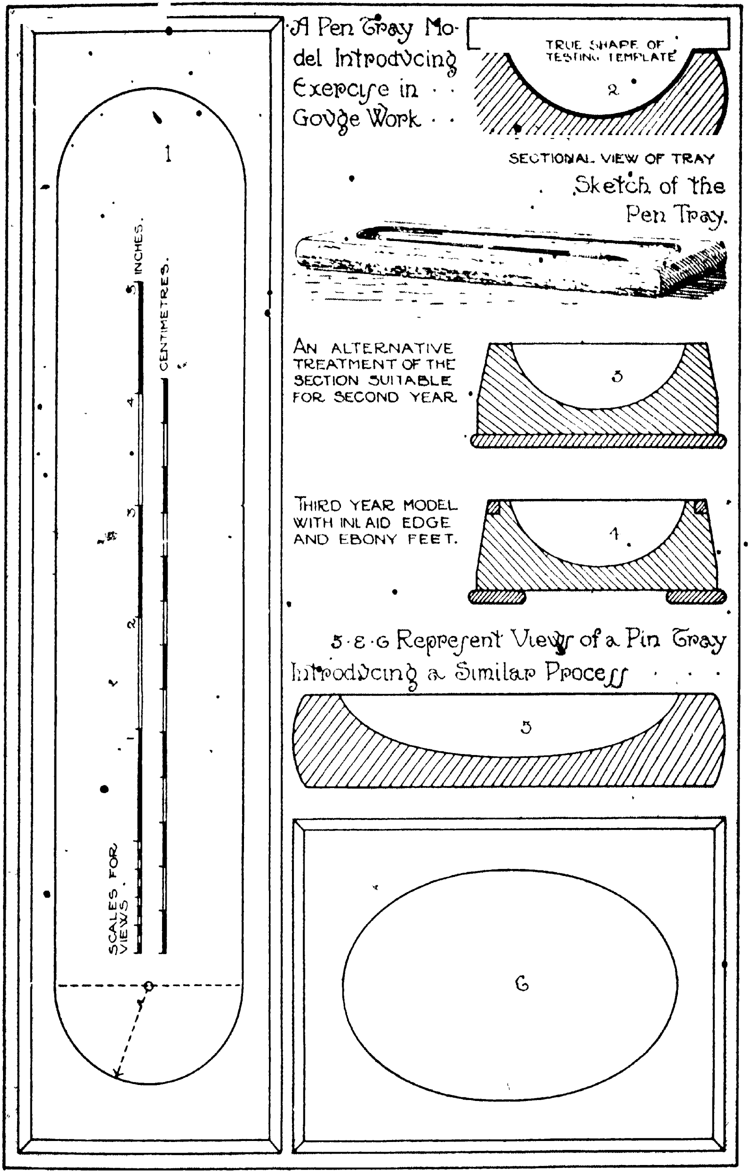

A Pen Tray Model Introducing Exercise in Gouge Work
TRUE SHAPE OF TESTING TEMPLATE
2
SECTIONAL VIEW OF TRAY
Sketch of the Pen Tray.
1
INCHES.
CENTIMETRES.
SCALES FOR VIEWS
5
4
3
2
1
AN ALTERNATIVE TREATMENT OF THE SECTION SUITABLE FOR SECOND YEAR.
3
THIRD YEAR MODEL WITH INLAID EDGE AND EBONY FEET.
4
5 & 6 Represent Views of a Pin Tray Introducing a Similar Process
5
6

FIG. 6.

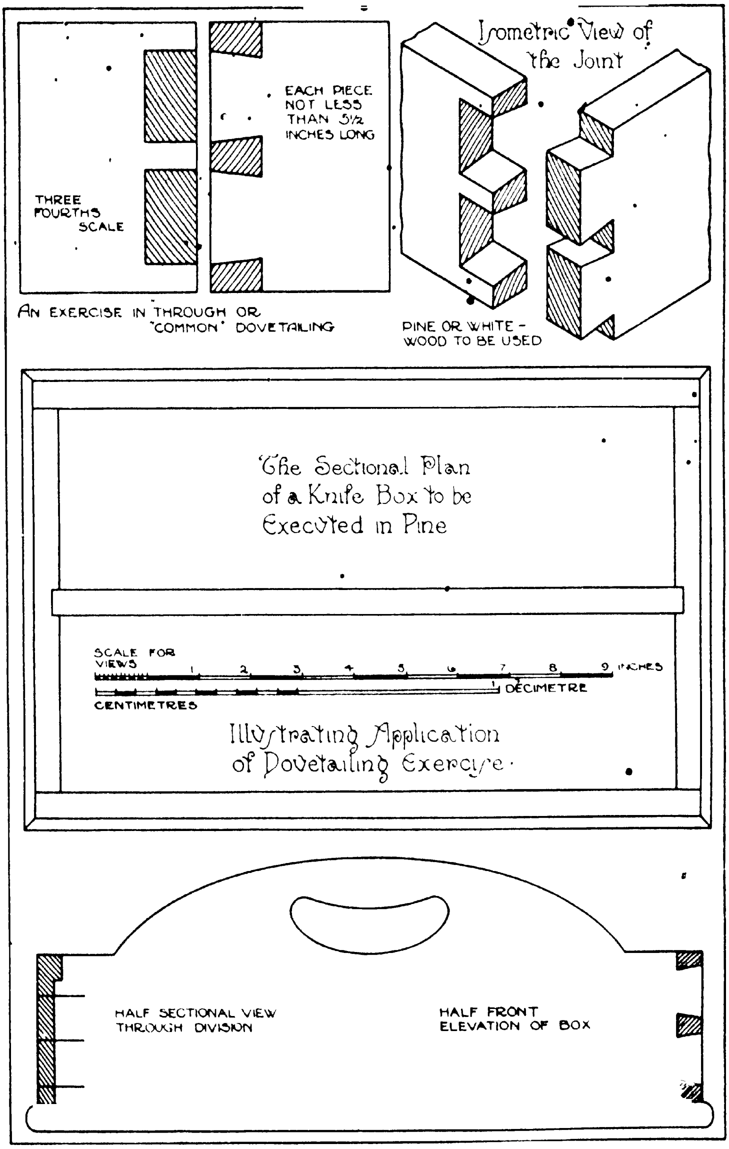

EACH PIECE NOT LESS THAN 5½ INCHES LONG
THREE FOURTHS SCALE
AN EXERCISE IN THROUGH OR "COMMON" DOVETAILING
Isometric View of the Joint
PINE OR WHITE-WOOD TO BE USED
The Sectional Plan of a Knife Box to be Executed in Pine
SCALE FOR VIEWS
1 2 3 4 5 6 7 8 9 INCHES
1 DECIMETRE
CENTIMETRES
Illustrating Application of Dovetailing Exercise
HALF SECTIONAL VIEW THROUGH DIVISION
HALF FRONT ELEVATION OF BOX

FIG. 1

ECTOR OF INDUSTRIES.
LIBRARY.
10

CHAPTER III

SECOND YEAR MODELS (WOOD)

KNIFE BOX (Fig. 1)

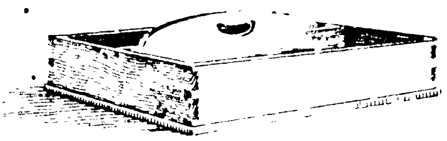
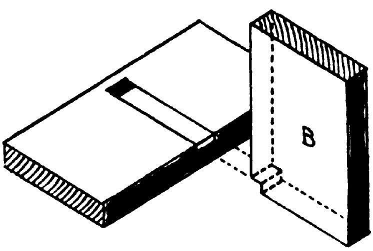


Fig. 2

Note. The knife box, detail drawings of which are shown in Fig. 1, perspective sketch in Fig. 2, should be made of American whitewood or yellow pine. If used for spoons, forks, etc., mahogany would be a more suitable material, the inside lined with green baize.

The Joints at the corners, viz. through dovetails, are illustrated opposite. It is recommended that one corner be taken as an exercise before proceeding with the complete model. A housed joint is used to connect the centre piece with the ends. The procedure for this is as follows:

1. Plane up to thickness and square to size two pieces American whitewood, 6 × 2½ × ½ in.



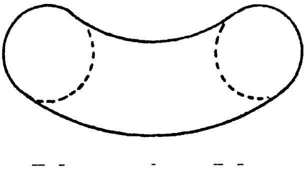


Fig. 3.

2. Square two lines across piece A, gauge ¼ in. deep on edge.

3. Cut away blackened part of diagram ¼ deep with firmer chisel. This permits the entrance of a dovetail saw and allows saw cuts to be made the required depth.

4. Remove waste, cut shoulder on piece B, and fit together.

Description of Fig 1 (continued).

The Process.—1. Saw out and plane to thickness the following material:—

	English.		Metric.
1 Bottom	1 ft. 1½ × 8½ × $\frac{7}{16}$ in.	yellow pine	34·5 × 21·5 × 1·2 cm.
2 Ends	8½ × 3 × $\frac{7}{16}$ in.	,,	21 × 7·5 × 1·2 cm.
2 Sides	1 ft. 1¼ × 3 × $\frac{7}{16}$ in.	,,	33·5 × 7·5 × 1·2 cm.
1 Division	1 ft. 0½ × 4¾ × $\frac{7}{16}$ in.	,,	31·5 × 12 × 1·2 cm.

2. Shoot face edges of all pieces, plane to length and width

3. Gauge for dovetailing, mark and cut same.

4. Set out and cut housed joints in division as per above.

5. Set out division, also hand hole as per Fig 3; and work same.

6. Glue up model, when dry, level off and fix in division.

7. Round edges of bottom and screw same to box.

A CLOCK CASE (Fig 4).

Object.—To produce a useful model embodying very elementary processes, viz. sawing, smoothing, shooting, grooving, and nailing. An American clock is utilized for the movement. This must have three small ears or flanges soldered to the sides (see sectional and back view) which provides for the necessary fixing. The bottom curve may be dispensed with if necessary.

The Process. 1. Prepare a working drawing of the model upon a ½ imperial sheet of cartridge paper, viz. full front elevation and a sectional view

2. Prepare also a cutting list or timber sheet from the drawing.

3 Saw out and plane up smooth the following material —

		English	Metric.
1 Front	whitewood,	10½ × 5½ × ⅜ in.	27 × 14·5 × 1 cm.
2 Sides	,,	10½ × 3¾ × ⅜ in.	27 × 9·5 × 1 cm.
1 Back	,,	10½ × 5½ × ⅜ in.	27 × 14·5 × 1 cm.
1 Top	,,	6¾ × 4 × ⅜ in.	17 × 10 × 1 cm.
1 Bottom	,,	5¾ × 2¾ × ⅜ in.	15 × 7 × 1 cm.

Shoot face edges of all.

4. Shoot face side of each piece on shooting board. Square also one end of each piece.

5. Place sides, back, and bottom together, and mark length across the three edges, also position of grooves (to receive bottom).

6. Mark bottom and top to finished length.

7. Saw and shoot all pieces to length; gauge and plane all pieces to width.

8. Round three edges of top, cut grooves and circular hole for face in front and back.

9. Nail sides on to bottom, then front between sides. Follow by nailing top down.

10 Fix the clock movement, and complete by nailing in the back

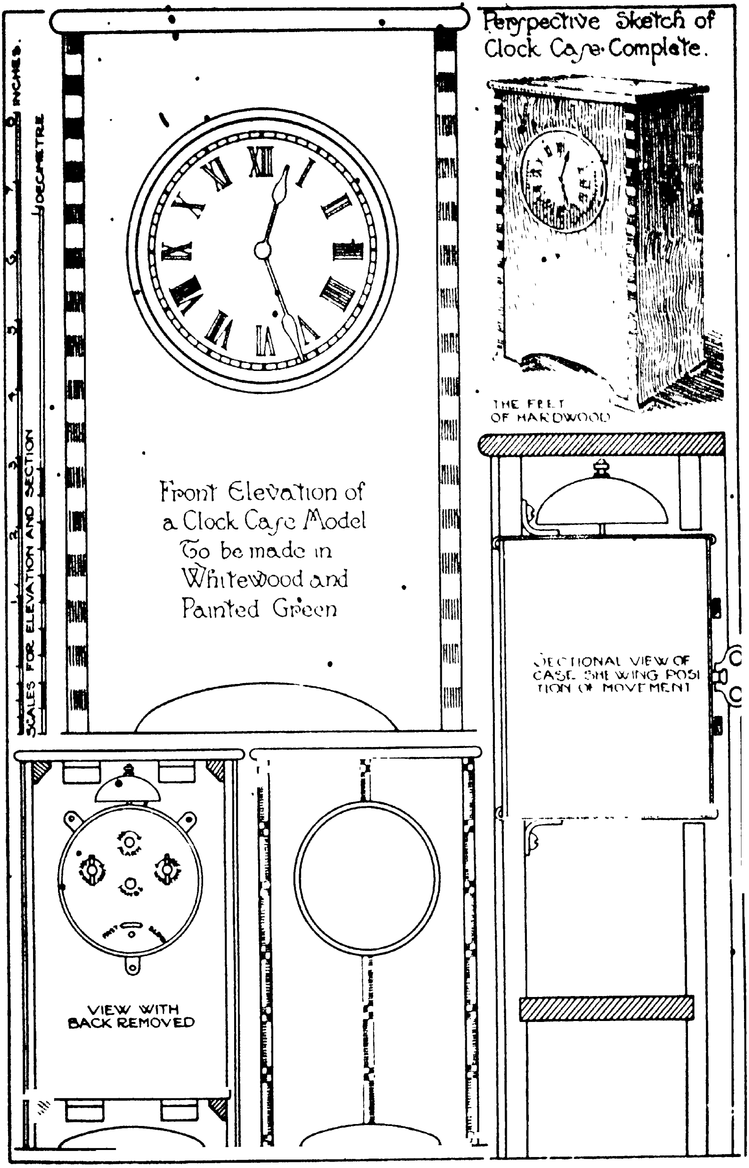

INCHES
DECIMETRE
SCALES FOR ELEVATION AND SECTION
Perspective Sketch of Clock Case Complete.
THE FRET OF HARDWOOD
Front Elevation of a Clock Case Model To be made in Whitewood and Painted Green
SECTIONAL VIEW OF CASE SHEWING POSITION OF MOVEMENT
VIEW WITH BACK REMOVED

FIG. 4.

GLOVE OR HANDKERCHIEF BOX (Fig. 5).

Object.—To embody elementary processes in a simple model. The first year example is whitewood nailed together with stencil decoration.

The second year example shows the application of through dovetailing, and introduces a simple form of decoration, viz. vee tooling with wax inlay.

The Joints of the first example are simply nailed or secured with panel pins; small pins or screws are fixed through the ends into the lid, acting as a pivot (see also plan of back corner shown); when the lid is raised the back edge rests against the box, and slopes slightly backwards.

The Processes for the first year model.

		English.	*Metric.*
1. Cut out 2 Ends	Whitewood,	6 × 4½ × ⅜ in	15·5 × 11 cm
„ „ 1 Front and Back	„	13 × 3⅛ × ⅜ in	34 × 8 cm.
„ „ 1 Bottom	„	14 × 6¼ × ⅜ in	36·5 × 15·75 cm.
„ „ 1 Top	„	12½ × 5¾ × ⅜ in.	31·5 × 14·75 cm.

2. Smooth up all material on both sides.

3. Square up to width and thickness back, front, top, and bottom.

4. Draw centre line on end, and draw half complete outline, duplicate on other side as follows:—

(*a*) Trace half outline into a piece of stiff tracing paper.

(*b*) Turn tracing paper over and go over the outline with a hard pencil; this will leave a mark on the wood, which should be lined in.

5. Repeat the outline on other side. Place both pieces together in bench vice, cut with fine bow-saw and finish with file.

6. Round the edges of bottom and front and back edges of the top.

7. Nail up the box as follows: Nail the ends on to the front, insert back and fix same. Fix the bottom, finally fit the top, mark centres as per diagram, and screw or pin.

The Decoration is based upon a simple natural growth. Pupils should prepare an outline from a specimen, then convert to a suitable stencil; this can be cut in ordinary cartridge paper with a sharp-pointed knife, and when placed in position on the box, the colour is dabbed on the wood through the cut-out portion; the paper is then removed and the paint allowed to dry.

The Second Year Example illustrates a slightly more difficult ornament. This should be drawn on cartridge paper first, then transferred to the box in the manner previously described. A vee tool is used to cut pattern, which can then be coloured or filled with coloured wax (see also p. 148).

Other suitable decorative patterns for use with this model are illustrated on pages 15 and 29.

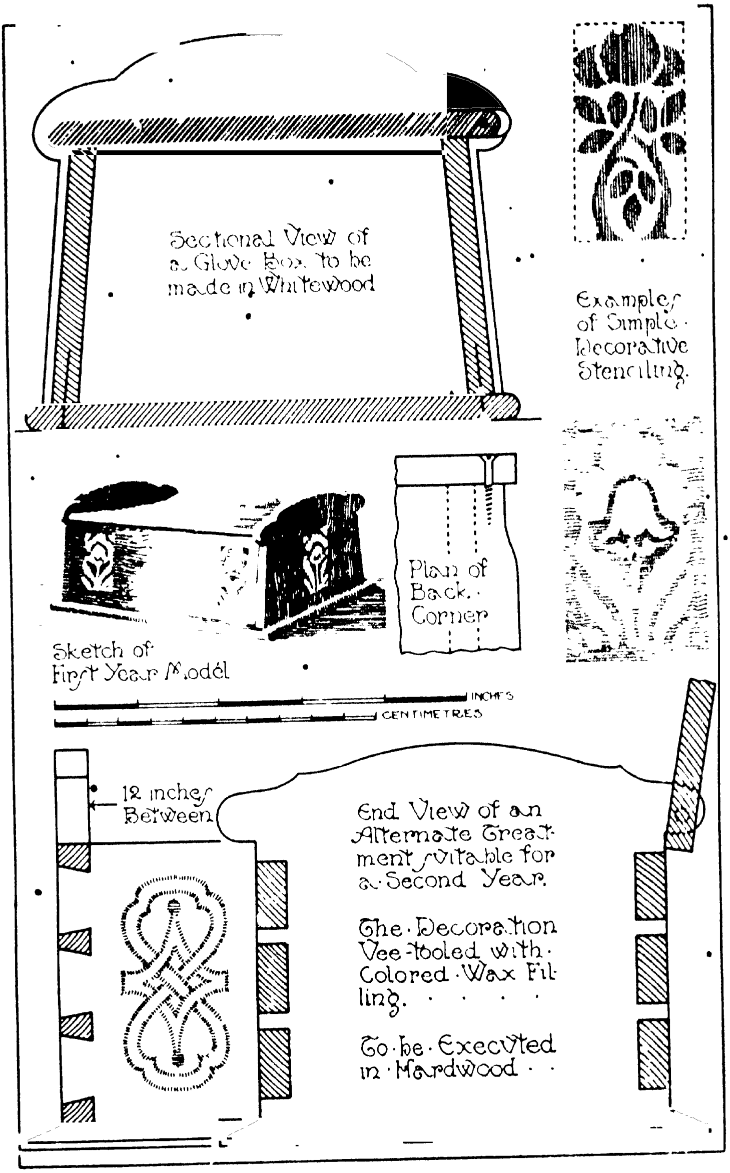

Sectional View of a Glove Box to be made in Whitewood
Example of Simple Decorative Stenciling.
Plan of Back Corner
Sketch of First Year Model
INCHES
CENTIMETRES
12 inches Between
End View of an Alternate Treatment suitable for a Second Year.
The Decoration Vee-tooled with Colored Wax Filling.
To be Executed in Hardwood

FIG. 5.

KNOCKER AND NAME PLATE (Fig. 7).

Note.—Though wood is not generally used for door knockers, some excellent specimens have been executed in this material, notably those at Gwydir Castle, Wales. In one a conventional rendering of a lion's head is the outstanding feature, while another example shows a pleasing application of chiselled work. An iron button is fixed below the actual knocker, which strikes against an iron plate cut into the door.

Name Plates, such as the example illustrated, can well be executed in wood. The lettering can be either recessed, or left in relief by gouging the outline (see examples, Fig. 6).

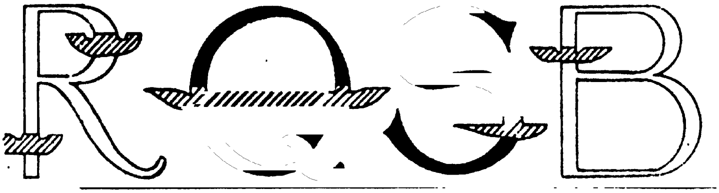


FIG. 6.

Oak is suitable material, left in natural condition with high parts coloured. Limewood is an easier material to use, but should be painted. Necessary boldness is given to the lettering, etc., by painting with a contrasting colour.

Processes.—The Name Plate.—The lettering is best executed by drawing upon cartridge paper. Good examples in various styles are given in Lewis F. Day's "Alphabets Old and New". Geometrical constructions are recommended. When a satisfactory design has been prepared, it can be transferred to the planed surface of the wood by the insertion of carbon paper between the design and the wood. A hard pencil is used to trace the outline, which leaves corresponding marks on the groundwork.

The letter R illustrated is cut round (as shown in section in Fig. 6) with a sharp gouge; the outside part of the gouge cuts is then pared down, producing the bottom section shown, the letter standing up in relief.

The letter Q illustrated should be gouged $\frac{1}{12}$ in. deep, square with groundwork, then gouged down as shown in section, leaving a V shape. In P a similar preliminary process is effected, then the back parts are removed with a "grounding-out" tool.

The letter B is the simplest to execute. Vee cuts are made, the sharp edge of the outside part being removed with a chisel.

For **The Knocker** the following procedure is satisfactory.—

1. Plane up material to thickness of ¾ in.
2. Draw centre line on wood, freehand strapwork design on one side, com-

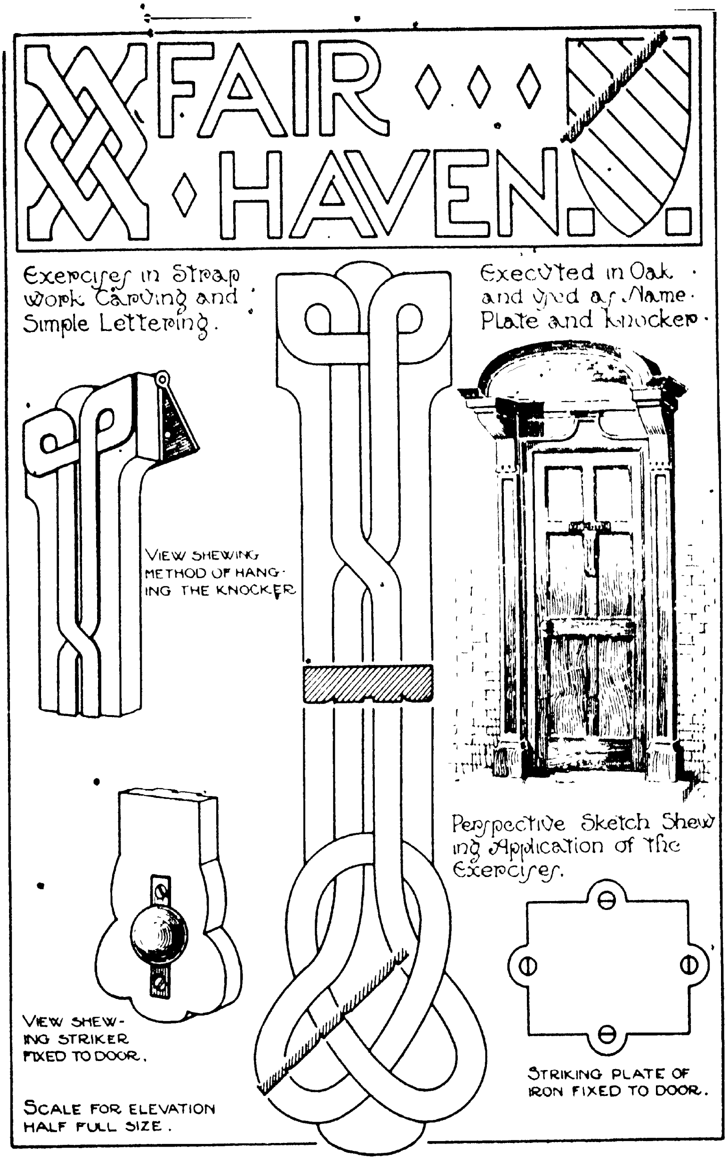

FAIR HAVEN.
Exercises in Strap Work Carving and Simple Lettering.
Executed in Oak and used as Name Plate and Knocker.
VIEW SHEWING METHOD OF HANGING THE KNOCKER
Perspective Sketch Shewing Application of the Exercises.
VIEW SHEWING STRIKER FIXED TO DOOR.
STRIKING PLATE OF IRON FIXED TO DOOR.
SCALE FOR ELEVATION HALF FULL SIZE.

FIG. 7.

Description of Fig. 7 (continued).

plete the other half with tracing paper, or draw on cartridge paper and transfer with carbon paper.

3. Outline the inside part of the design with chisels and gouges and cut down back parts as shown in the section.

4. Cut outside of shape with bow-saw and finish with file.

5. Fix hinge, button, and striking plate.

Object.—To introduce simple carved exercises—involving good training of hand and eye—as a complete model.

A TABLE BOOK-STAND (Figs. 8 and 9)

Object.—To show an application of lapped dovetailing to a simple model. Also to introduce simple chamfered moulding, shaping, and inlaying. The length of the model can conveniently range from 11 in. over all size (as per example) to 2 ft. over all size.

The Joints.—Mitreing is used for the base moulding, and lapped dovetailing is a variation of through or common dovetailing illustrated on p. 18.

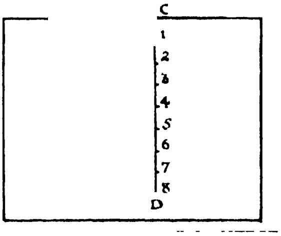


FIG. 8.

The best angle for dovetailing, either through or lapped, is 1 in 6; the carcase and secret dovetails 1 in 6. The best method of obtaining the correct angle is to draw a line CD in Fig. 8 4½ in. long. Then to divide it into six equal parts; one of these divisions should be drawn at right angles to D and a sliding bevel can then be adjusted. One-eighth the length of D can be substituted for the divisions if desired.

Procedure.—For the exercise No. 1, Fig. 9:—

1. Plane up pieces to width and thickness.

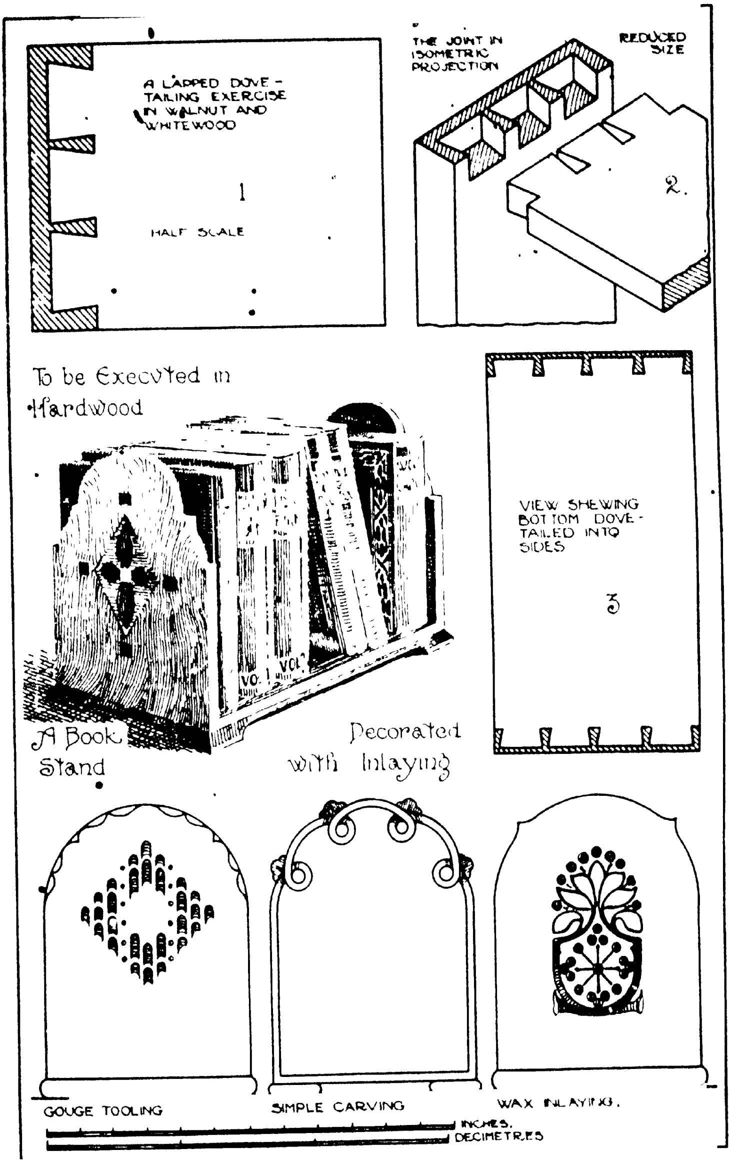
2. Square one end of each piece.

3. Decide length of dovetail, rather more than two-thirds thickness of socket piece, gauge same on both pieces.

4. Space out dovetails, marking same with the bevel.

5. Cut dovetails, and then fix the thick piece in the bench chop. The end of the thin piece should then be lined up with the gauge mark of the cap, and held firmly in position. This can best be effected by placing the end of the dovetailed piece upon a plane or block. Press firmly down, place saw in cut, and draw forward. A mark will result in each instance. The guide piece can then be removed, and the socket piece reversed, then cuts are made with dovetail saw, *leaving the mark upon* the wood. Complete by chiselling out sockets and waste, cut shoulders with dovetail saw.

The Process.—1. Plane up to width and length.—


A LAPPED DOVE-TAILING EXERCISE IN WALNUT AND WHITEWOOD
1
HALF SCALE
THE JOINT IN ISOMETRIC PROJECTION
REDUCED SIZE
2.
To be Executed in Hardwood
VOL. I
VOL. II
A Book Stand
Decorated with Inlaying
VIEW SHEWING BOTTOM DOVE-TAILED INTO SIDES
3
GOUGE TOOLING
SIMPLE CARVING
WAX INLAYING.
INCHES.
DECIMETRES

Description of Fig. 9 (continued).

	English.	*Metric.*
2 pieces for Ends	7¾ × 6¼ in.	19·5 × 15·5 cm.

2. Saw out and plane up to thickness:—

1 piece for Bottom	11 × 6¼ in.	28 × 15·5 cm.
Moulding, 1 length	3 ft. 2 × 2¼ in	97 × 6 cm.

3. Shoot bottom to length and width, plane ends to width, and square one end.

4. Plane moulding to width and thickness

5. Dovetail bottom into ends (as per preceding detail).

6. Mark centre lines on ends, draw shape on half, and duplicate with tracing paper and templet.

7. Cut and regulate shapes, paper up same

8. Set out inlaying as per perspective sketch, or carving, tooling, or stencilled decoration (see bottom diagrams).

9. Sandpaper up all parts; glue together; when dry level off bottom and edges, and mitre round the moulding.

TEA TRAYS (Fig. 10).

Object.—A useful model showing the application of a simple angle joint, viz. tongueing In the case of the alternate constructive detail shown, viz. diminished and housed dovetailing, this is more suitable for second and third year work, when a greater degree of proficiency has been attained.

The Process (for main elevation and sectional view).—First year model. Prepare and plane up to thickness the following material.—

	English.	*Metric.*
1. Bottom	1 ft. 4 × 11½ × ½ in.	40 × 29 × 1 cm.
2. Sides	1 ft. 3½ × 1¼ × ½ in.	39 × 3·2 × 1 cm.
3. Ends	11 × 1¾ × ½ in.	26·5 × 4·5 × 1 cm.

A scale of one-fifth full size could be adopted with advantage in some cases; the cutting sizes would then be as follows:—

1. Bottom	1 ft. 8 × 13⅞ × ½ in.	50 × 36·25 × 1·25 cm.
2. Sides	1 ft. 5 × 1⅝ × ½ in.	48·75 × 4 × 1·25 cm.
3. Ends	1 ft. 1¾ × 2⅛ × ½ in	33·1 × 5·6 × 1·25 cm.

1. Plane sides to width, place same together in bench vice, mark finished length on edges, and also the grooves to receive tongue.

2. Place ends in bench vice, set out finished length on edges, also shoulder line.

3. Gauge on thickness of tongue, cut same with dovetail saw. Cut grooves on sides and fit the frame together.

4. Set out shape of end, as per diagram on this page.

5. Bore holes for handles, finish with keyhole saw and files.

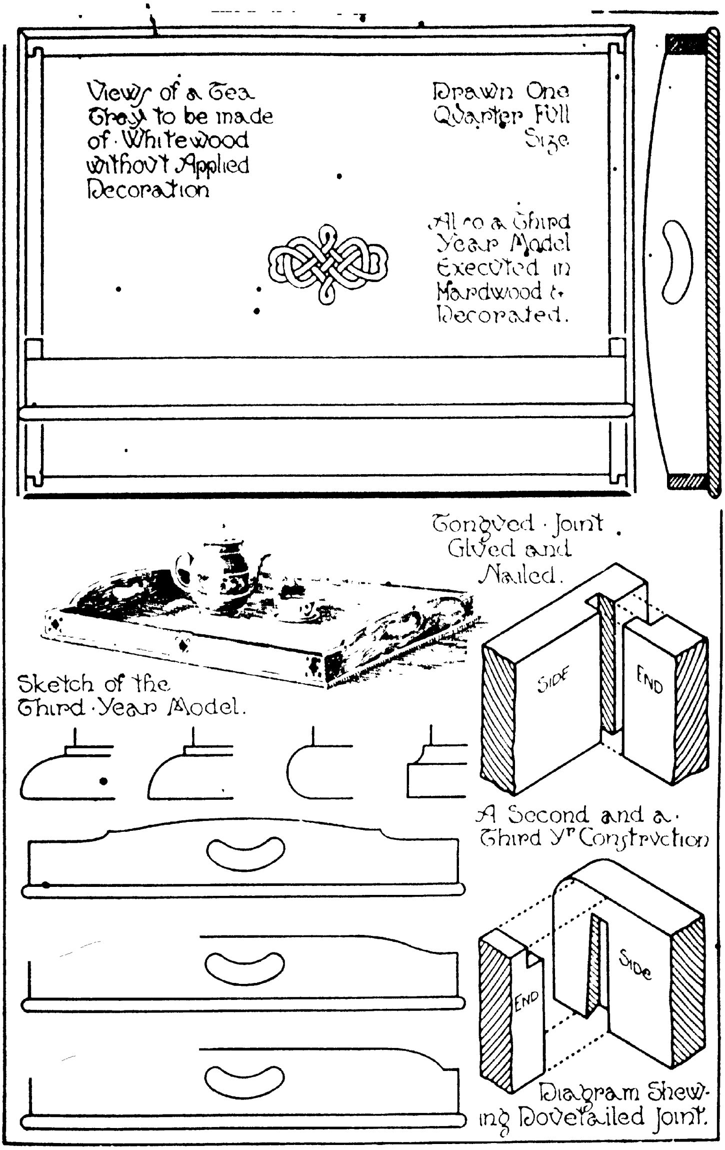

View of a Tea Tray to be made of Whitewood without Applied Decoration
Drawn One Quarter Full Size
Also a Third Year Model Executed in Hardwood & Decorated.
Tongued Joint Glued and Nailed.
Sketch of the Third Year Model.
SIDE
END
A Second and a Third Yr Construction
END
SIDE
Diagram Shewing Dovetailed Joint.

FIG. 10.

6. Cut top curve, finish with spokeshave, glue together, and when dry plane up framing all round.

The Decoration of a first or second year model should be restricted to a simple arrangement of gouge cuts or vee tooling. For the third year a strap-work design is shown which is executed by cutting the groundwork away slightly so as to leave the design in relief. Its effect is enhanced if the surface of the strap-work is cut slightly hollow.

Simple decoration could also be introduced round framing, as suggested in the perspective sketch.

Alternate Shapes for the ends are illustrated, these could be supplemented indefinitely. For class work it is recommended that pupils be given definite data for the hand holes, and be allowed to express their own ideas for the outline, subject of course to criticism and guidance. Alternate details are also shown suitable for a moulded bottom.

CHAPTER IV

THIRD YEAR MODELS (WOOD)

A HANGING LAMP BRACKET (Fig. 1)

Object. A model designed chiefly to introduce shaping, cutting with bow saw, and working with spokeshave and file. Also as an exercise in simple recessing.

The Joints introduced are a simple mortise and tenon joint, and secret screwed fixing described below.

Decoration in the example illustrated is a simple outline vee tooled, one side of the cut having the sharp edge removed (see section on front elevation). The background can be coloured for effect, certain shades of blue, green, or red harmonizing well with oak.

The Process. –

1. Prepare.

	English	*Metric*
1 piece for Back	14 × 6 in.	35·5 × 15·25 cm.
1 " " Shelf	9 × 8 in.	23 × 20·5 cm.
1 " " Bracket	6¼ × 2½ in.	16 × 6·5 cm.

2. Plane up each piece to thickness, reduce back only to width.

3. Mark a centre line on back, freehand the curve on left side, duplicate right-hand side with tracing paper.

4. Plane one edge of shelf, set out shape with compasses.

5. Plane one edge of bracket, set out shape with compasses.

6. Gauge mortise on back (both sides) and tenon on bracket. Bore ⅜ in. hole and finish mortise with firmer chisel.

7. Slot screw the bracket on to the shelf (see later).

8. Fix back in bench vice, and saw curves ($\frac{1}{16}$ in. outside line) with bow saw. Repeat process with bracket and shelf.

9. Finish each piece with spokeshave, file, and glass-paper.

10. Draw design on back, and outline with vee tool.

11. With a small firmer chisel merge one line of the cut on to the background.

12. Clean up all surfaces, and screw the model together.

13. Paint in background of recessing.

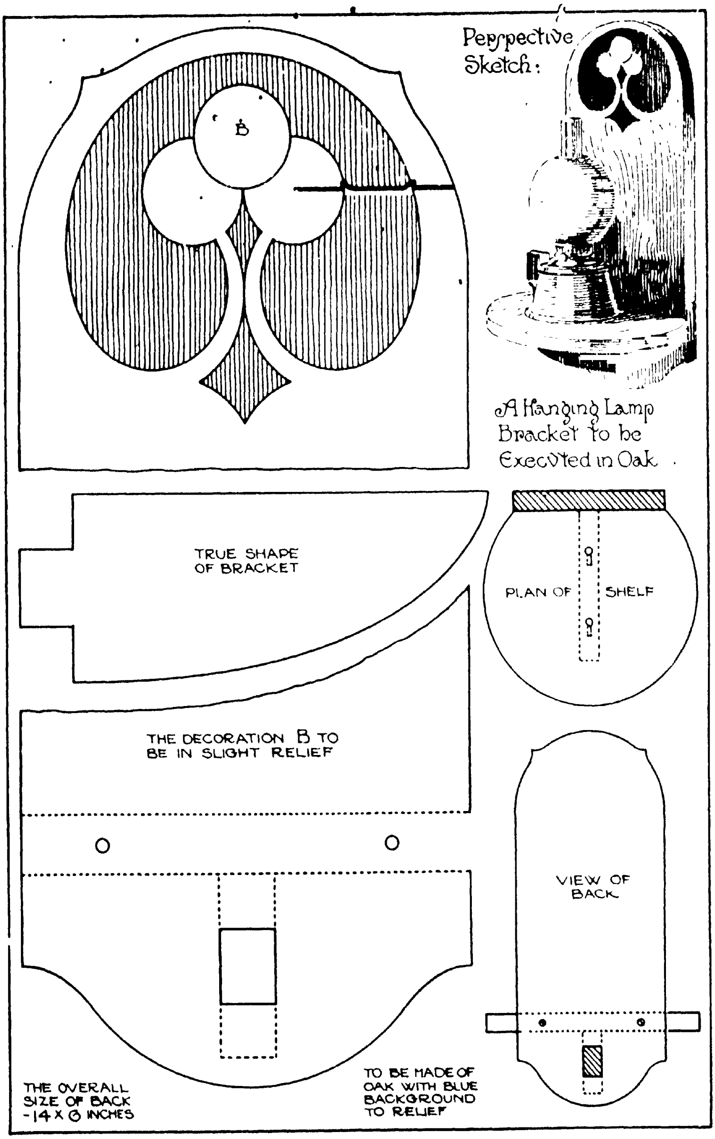

Perspective Sketch:
B
A Hanging Lamp Bracket to be Executed in Oak.
TRUE SHAPE OF BRACKET
PLAN OF SHELF
THE DECORATION B TO BE IN SLIGHT RELIEF
VIEW OF BACK
THE OVERALL SIZE OF BACK - 14 X 6 INCHES
TO BE MADE OF OAK WITH BLUE BACKGROUND TO RELIEF

FIG. 1.

Slot Screwing.

1. The bracket piece (A in diagram) should have two ¾ in. × 6 in. screws driven in until a projection of ¼ in. is obtained.

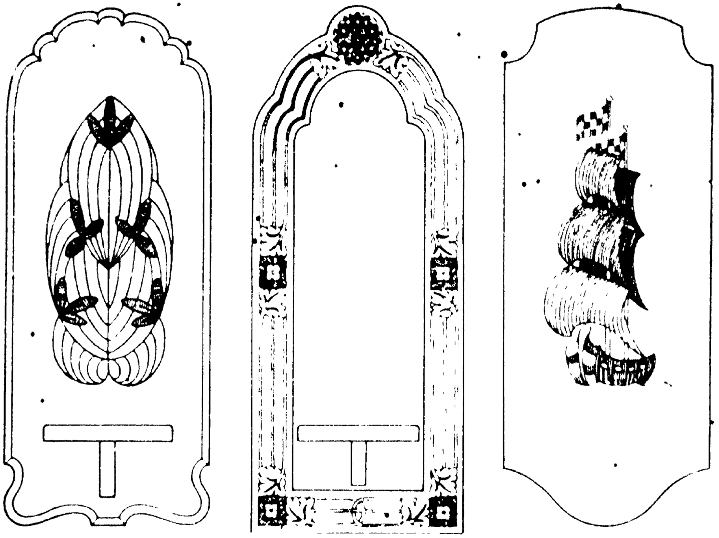


FIG. 2. Alternate decorative treatments for back of lamp bracket—see tooled, painted and inlaid.

2. The centre of these screws should be marked on the underside of shelf, then holes are bored exactly the size of the screw head ¼ in. deep.

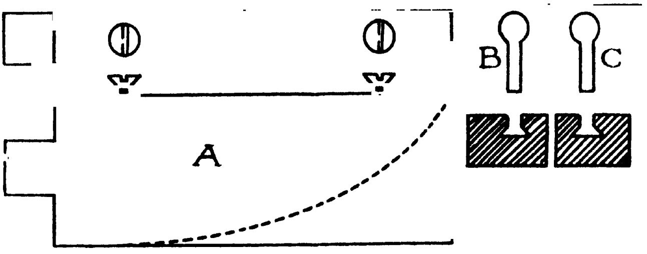


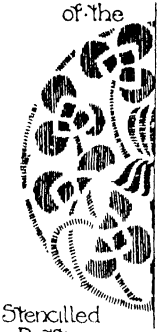
FIG. 3.

3. Slots are cut in the shelf (see plan in Fig. 1) coinciding with the thickness of the screw shaft. See B in diagram.

4. With a small firmer chisel bevel the inside of slot to coincide with the bevel of screw head underneath. The screw heads can then be entered in the bored holes, the bracket pressed down, and tapped along the grooves with a hammer, thus forming a secret screwed joint.

MIRROR OR PICTURE FRAMES (Figs. 4–7).

Tooled, Inlayed, and Stencilled.



Object.—To show applications of a long and short shouldered mortise and tenon joint to a tenoned-up frame. Three shapes are illustrated, embodying similar constructive features. The ornament is varied, the first type shows an arrangement of simple gouge cuts, the second—without shaping—shows a simple inlaid treatment, and the third example illustrates the application of stencilled ornament.

The Joint (see diagram) as an exercise is best cut from two pieces of pine or whitewood 8 × 2 × ⅞ in. These are planed to width and thickness, and then set out as illustrated in Fig. 4, below.

1. Square across lines on stile piece to width of rail AB.
2. Square across rebate line and haunch line CD.
3. Square shoulder lines across on rail piece EF 1¼ in. from end.
4. Return E on face side, F on back side.
5. Set gauge to mortise chisel (⅓rd approx.)
6. Mark mortise on stile and tenons on rails (see dotted lines).
7. Mortise stile, cut tenons, and then fit together.

The Process for Frame (first example).—1. Saw out, and plane up to width and thickness.—

	English.	*Metric.*
2 Stiles	1 ft. 1 × 1¼ in.	2 pieces 33 cm.
1 Top rail	1 ft. 4 × 3¼ in.	1 piece 41 cm.
1 Bottom rail	1 ft. 4 × 1¼ in.	1 piece 41 cm.

2. Place stiles together in bench vice and square across sight lines of rails, then haunch and rebate lines, gauge rebate lines on face, edges, and backs.

3. Mark mortise and tenons, cut same, then shoulders, work the rebates with plane (see p. 194, Fig. 10).

4. Firmly secure one stile in bench, then reduce tenon to width; test same in mortise and fit same until both shoulders are tight, and rail lies in the same plane as the stile.

5. Repeat this process with each remaining corner of the frame.

6. Glass-paper inside edges and glue frame together. (Iron stops of bench used for one end, with light iron cramp across the other rail.)

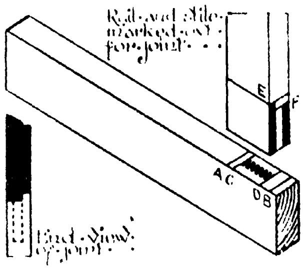


FIG. 4.

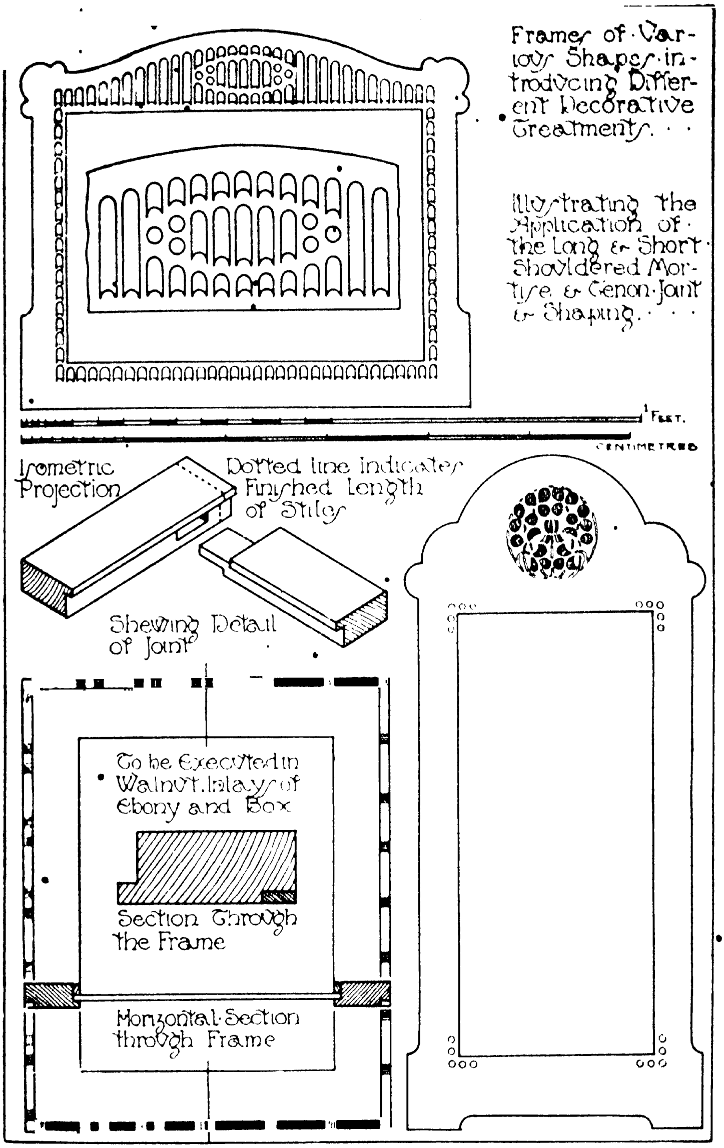

Frames of Various Shapes introducing Different Decorative Treatments.
Illustrating the Application of the Long & Short Shouldered Mortise & Tenon Joint & Shaping.
1 Feet.
Centimetres
Isometric Projection
Dotted line Indicates Finished Length of Stiles
Shewing Detail of Joint
To be Executed in Walnut. Inlays of Ebony and Box
Section Through the Frame
Horizontal Section through Frame

Fig. 5.—Frames.

7. When dry, the frame is planed down level on both sides, and a centre line drawn on face side; the curves are then traced on paper from the full-size drawing and transferred half at a time each side of centre line.

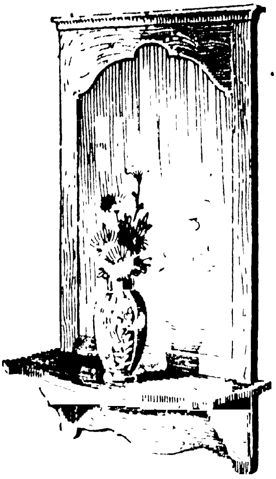


FIG. 6.—A shaving mirror to hang upon a wall. Executed in white-wood and painted.

8. Frame is placed in bench vice, shape cut just outside the line with a bow saw, then filed and regulated, viz. freed from lumps and irregularities, and finally papered up.

9. Tooling is spaced out with dividers and drawn upon the wood, then a scribing gouge is used to tool the surface. Papering concludes this part, and the addition of a back from ¼ in. pine completes the model.

CANDLE BRACKET (Fig. 7).

Object.—To show the possibility of combining metal and woodworking processes in one model.

The Joints employed in the woodworking portion are a double mortise and tenon joint, with single ditto on bracket, and secret screwing to secure bracket to shelf. The candle sconce is intended to be screwed down to the bracket.

The Process. 1. The model to be drawn on cartridge paper, full size.

2. Saw out and plane to width and thickness:—

	English.	*Metric.*
1 piece Back	10½ × 4½ × ⅝ in.	27·5 × 11·5 × 1·6 cm.
1 „ Bracket	6 × 1½ × ½ in.	15·5 × 3·5 × 1·3 cm.
1 „ Shelf	6½ × 3¼ × ½ in.	8 × 8·25 × 1·3 cm.

3. Draw centre line on back. Square across lines for mortise, and mark outline with tracing paper.

4. Set out shoulder and tenons on bracket, cut same, also mortise and tenon in back and fit together.

5. Execute the secret screwing in bracket and shelf (see p. 33).

6. Set out true shape of bracket and shelf, cut same, also the back; spokeshave, file and glass-paper to line.

7. Execute inlaying as per below, then clean up all surfaces and glue together. Fit sconce and fix.

The Decoration of the example under review is wood inlaying; this can, alternately, be entirely omitted, or simple carving, strapwork, stencilling, or

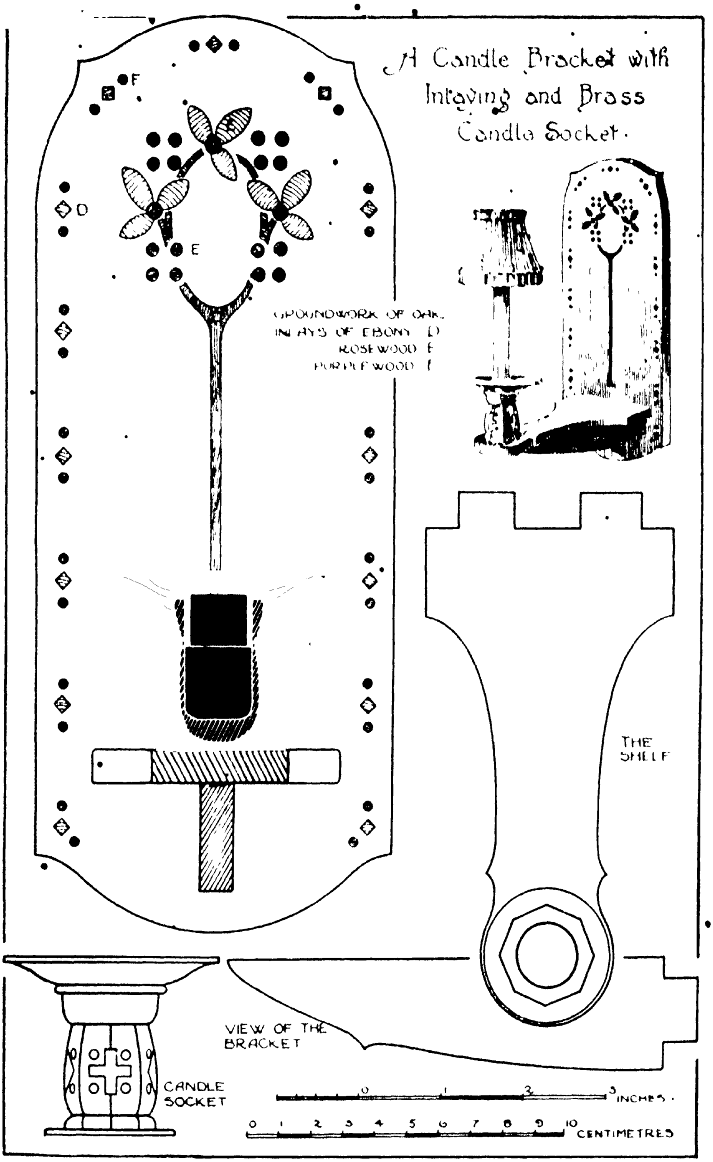

A Candle Bracket with Inlaying and Brass Candle Socket.
F
D
E
GROUNDWORK OF OAK
INLAYS OF EBONY D
ROSEWOOD E
PURPLE WOOD F
THE SHELF
VIEW OF THE BRACKET
CANDLE SOCKET
0 1 2 3 INCHES.
0 1 2 3 4 5 6 7 8 9 10 CENTIMETRES

FIG. 7.

tooling can be substituted. (References to the latter with suitable ideas will be found on opposite page and on p. 144.)

Procedure for Inlaying.—It is assumed that the ornament is drawn full size on cartridge paper.

1. Trace the pattern on to tracing paper. Gum or paste this down to the back in correct position.
2. Prepare another tracing of the inlay, cut up into small pieces, each containing one unit of the design (or alternately), as described on p. 145. Glue these tracings of units down to veneer, taking care to have the grain running from heel to point of each leaf.
3. Cut leaves and stems with fret saw or gouge, keeping just *outside the line.*
4. Gouge groundwork, cutting just inside the line, remove cores, and glue units in position.
5. Bore the spot units, and glue in previously prepared sticks.
6. The square units are cut with ¼ in. chisel.

FINGER PLATES (Fig. 8).

Object.—To introduce various exercises in a complete model, involving manipulation of gouges and grounding tools as special practice for hand and eye.

Note.—The third, fourth and fifth examples represent those placed beneath the handle and lock of a door, and the length can readily be extended for upper plates. Many alternate arrangements can be effected, such as carving on top of upper plate, and vice versa. When extra length is desired, the ornament is such as to be readily adaptable.

The Process. A full-size drawing of a plate should first be made on cartridge paper, then the wood selected. The following woods are suitable, and range in difficulty of working in the order given, viz. Mahogany, walnut, oak, sycamore, boxwood, ebony, and satinwood.

First Example.—1. Cut out and plane to width and thickness:—

English.				*Metric.*
Top plate 1 piece	hardwood	11 × 3 × ¼ in.	base	28 × 7·6 × ·6 cm.
Bottom plate 1 piece	"	8 × 3 × ¼ in.	"	20·3 × 7·6 × ·6 cm.

2. Draw centre line on each piece. Trace half the outline on plate and ornament from drawing.
3. Transfer this on both sides of centre lines with tracing paper.
4. Clamp wood on bench, and outline design with carving gouges.
5. With a grounding-out tool remove interior parts to a uniform depth, keeping corners sharp.
6. Cut the face of the ornament to give an interlacing effect.
7. Complete the model by cutting outline, rounding of same on face side, and sandpaper up the flat surface.

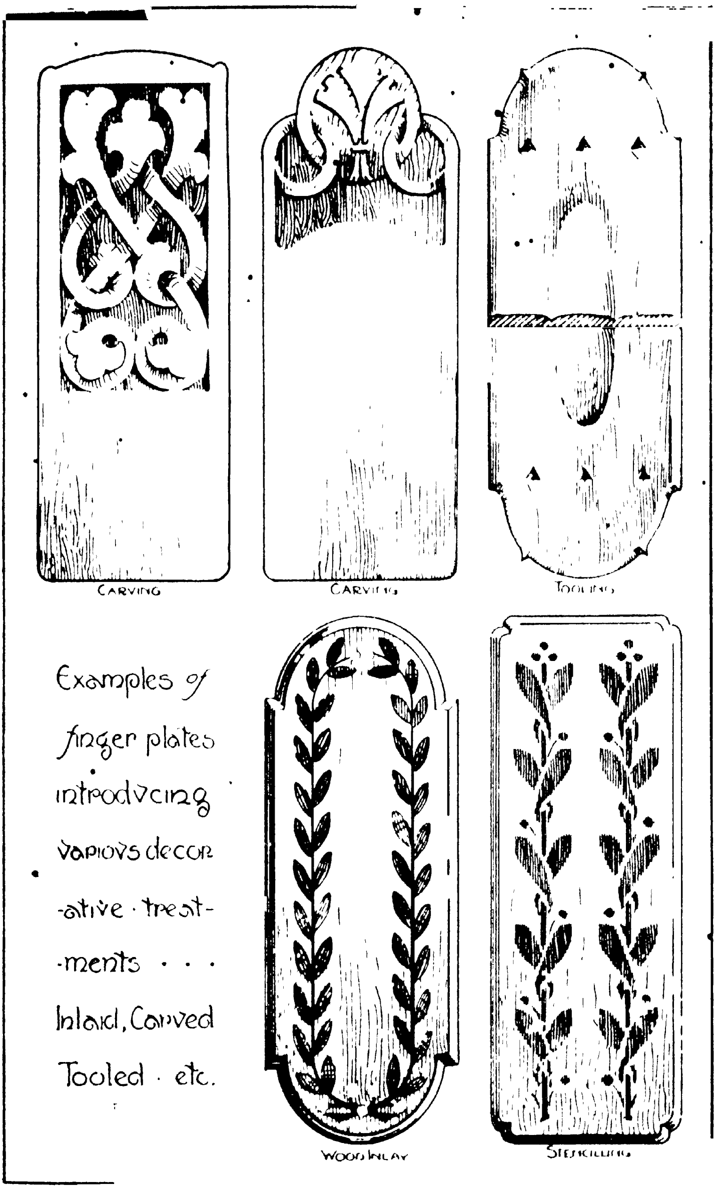

Carving
Carving
Tooling
Examples of finger plates introducing various decorative treatments . . . Inlaid, Carved Tooled · etc.
Wood Inlay
Stencilling

FIG. 8.

Fourth Example.—1. Prepare material (as per above) and transfer detail from drawing with tracing paper.

2. The stems should be cut from veneer, and cut into the groundwork and glued.

3. The leaf units are next cut. They are best made by two gouge cuts in a leaf of veneer, and may be cut into the groundwork in a similar manner. Two gouge cuts are made the required depth, and a slight turn of the tool usually suffices to remove the core.

4. Units are glued in position, holes are bored for the berries with a small twist or centre bit, and a cylindrical stick, equal in diameter to the berry, is prepared, and can be glued into a hole and cut off level with a dovetail saw.

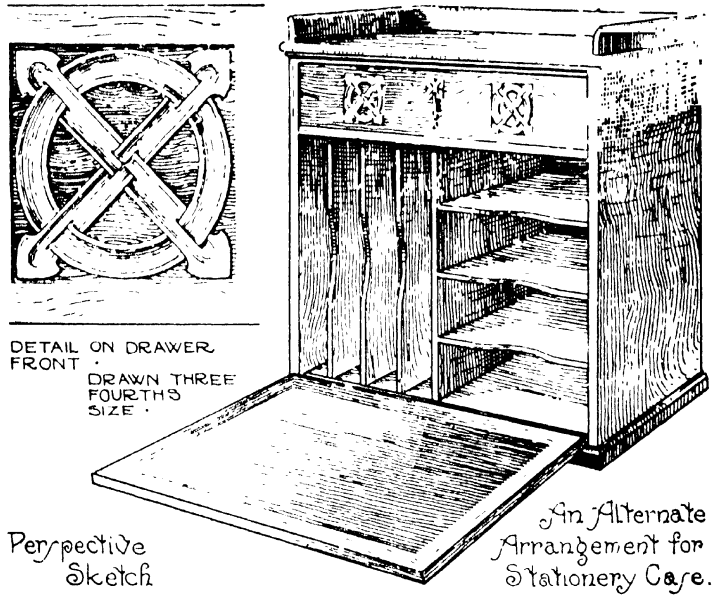

DETAIL ON DRAWER FRONT ·
DRAWN THREE FOURTHS SIZE ·
Perspective Sketch
An Alternate Arrangement for Stationery Case.

FIG. 9 —A design for a simple carcase model. A stationery case.

Inlaying is further described in chapter on "Decorative Processes".

The ornament shown in the second example should be executed by first outlining the ellipse with gouges, and then bevelling as indicated with flat carving tools.

BREAD PLATTERS (Fig. 10).

Object.—To introduce bow sawing and filing exercises. These models are specially valuable for good hand and eye training. Whilst general features are followed, there is ample scope for individual taste on the part of pupils.

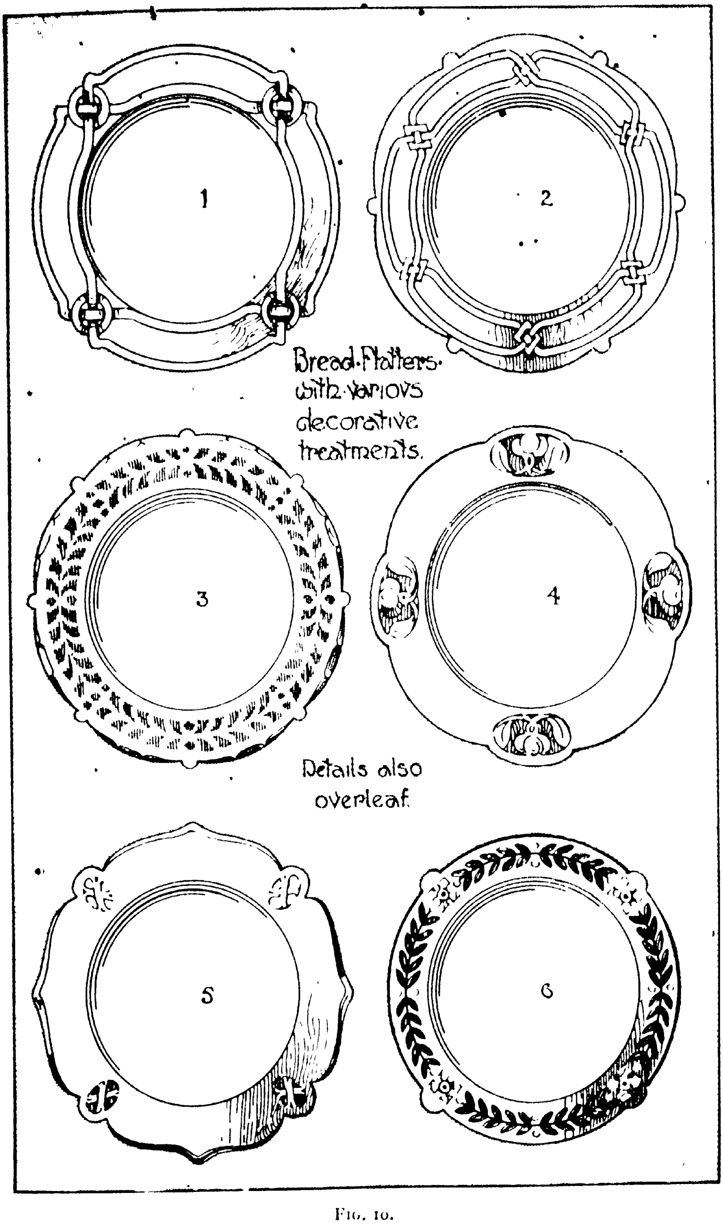

1
2
Bread-Platters with various decorative treatments.
3
4
Details also overleaf.
5
6

FIG. 10.

Commencing with the drawing of a plain circle for outline and an inner circle for the recessing, individual effort can be encouraged in developing the outline, chamfering, and ornament of rim

Material.—Sycamore is an excellent wood for this model; limewood may be considered the next best; it is both softer and easier to work than the former. American whitewood is least satisfactory for class work owing to its liability to cast and twist. An average overall size of 12 in. is recommended.

The Process (example No. 1, Fig. 10).—1. Prepare a drawing of the platter, full size, on cartridge paper.

2. Plane up the material on both sides and strike diagonal lines.

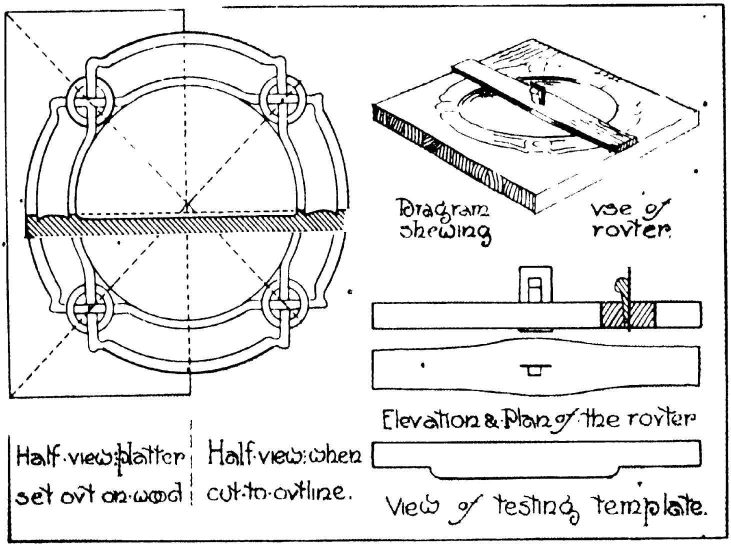


Diagram shewing use of router
Elevation & Plan of the router
Half-view: platter set out on wood
Half-view: when cut to outline.
View of testing template.

FIG. 11.

3. Transfer the design on to the material.

4. Execute the recessing; this should be done with a flat gouge. (Occasionally it should be tested for correct depth with the templet (see diagram). A router is used to finish the recessing to a uniform depth (see sketch above). Glass-paper can be used to finally smooth up.)

5. Cut outline to shape with bow saw, and finish with file.

6. Execute carving with gouge cuts square to face side, the groundwork is then levelled (see section above), leaving the strapwork or leaves, etc., in relief.

7. Complete the model by spacing and pencilling the chamfer decoration, file this part, and finish with sandpaper.

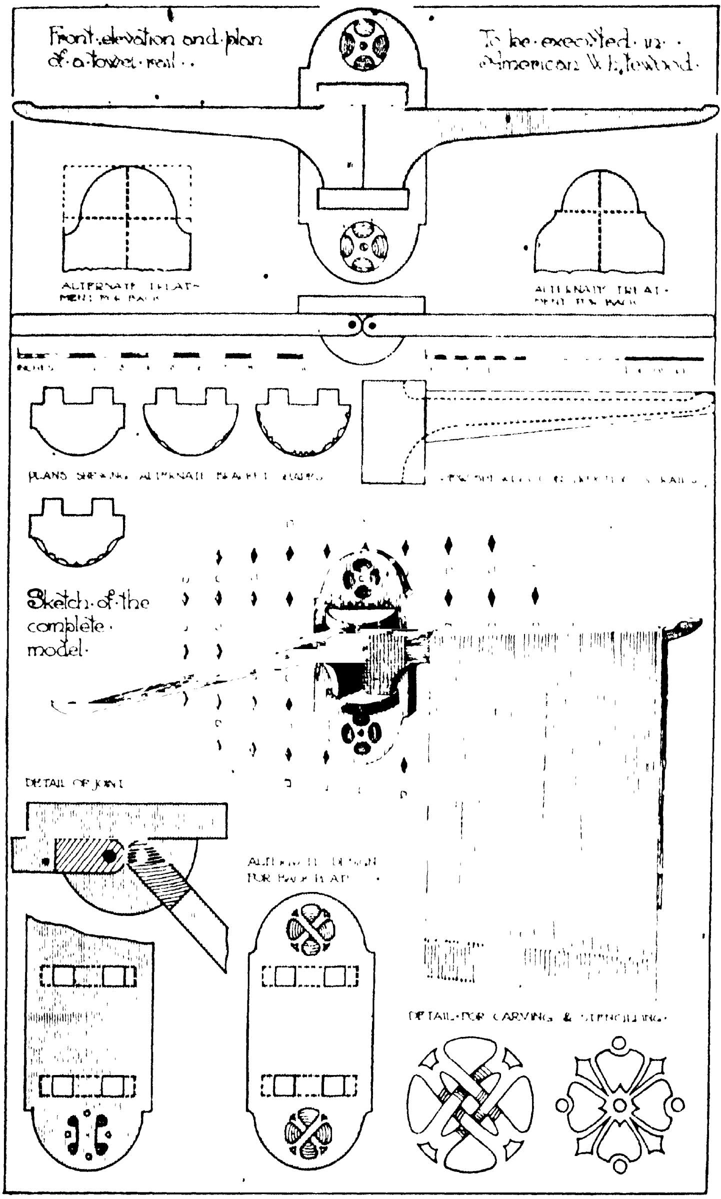

Front elevation and plan of a towel rail
To be executed in American Whitewood
ALTERNATE TREATMENT FOR BACK
ALTERNATE TREATMENT FOR BACK
INCHES
PLANS SHEWING ALTERNATE BRACKET ENDS
Sketch of the complete model
DETAIL OF JOINT
ALTERNATE DESIGN FOR BACK PLATE
DETAIL FOR CARVING & STENCILLING

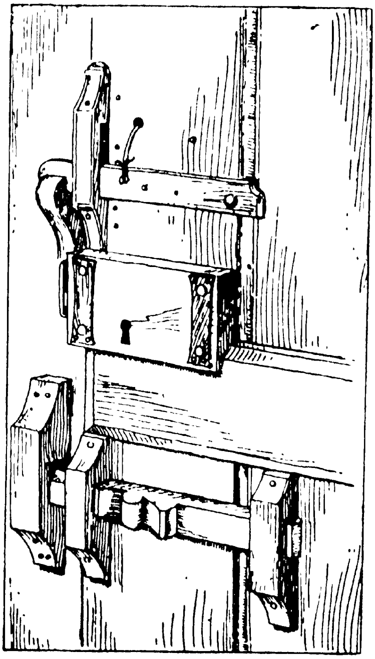
FIG. 12.—An adjustable towel rail to be made in teak, sycamore, or American whitewood.

Description of Fig. 10 (*continued*).

Notes.—The first example, described above, is worked upon a circular geometrical basis, the decoration is centred upon diagonal lines. The second specimen has a hexagonal form, the sides being converted into curves with small intervening detail. The main elements of the strapwork decoration are spaced in between the diagonals. The third example is based upon an octagon, and the leaf decoration is intended to be slightly recessed.

No. 4 is based upon a circular outline, with simple conventional floral ornament at the ends of the diameters.

No. 5 shows an example worked upon a circle and diagonal lines, as does also the last specimen, the decoration in this case being in slight relief from the rim or groundwork.



Wooden Latch and Bolt from a house at Brockhampton, Herefordshire.

CHAPTER V

SPECIAL MODELS IN WOOD

FOR EVENING PUPILS AND OTHERS

SWING TOILET MIRROR (Fig. I)

Object.—A model designed chiefly upon the use of mortise and tenon joints, and to show the application of simple geometrical painted decoration, strapwork carving, or recessing and chamfered ornament.

The Joints.—All of the joints connecting the various parts are similar, i.e. mortise and tenon.

The Procedure for complete example illustrated is as follows:—

Mark and saw out the following pieces:—

		English.	*Metric.*
1. Standards	2 pieces	1 ft. 5¾ in. × 3 × ¾ in.	45 × 7 × 2 cm.
2. Feet	2 ,,	7 in. × 1¼ × ¾ in.	17·5 × 3 × 2 cm.
3. Cross Rail	1 piece	1 ft. 7 in. × 3¼ × ¾ in.	48 × 7·5 × 2 cm.
4. Capping	1 ,,	7 in. × 1 × ¼ in.	17 × 3 × 5 cm.
5. Stiles	2 pieces	1 ft. 1½ in. × 1 × ⅞ in.	34 × 2·5 × 2 cm.
6. Rails	2 ,,	1 ft. 5 in. × 1 × ⅞ in.	41·5 × 2·5 × 2 cm.
7. Glass Back	1 piece	1 ft. 4 in. × 11½ × $\frac{3}{16}$ in.	40 × 29 × ·8 cm.

8. Plane up face, side, and edge of all material.

9. Gauge and plane all pieces to width and thickness as per drawing (with exception of back).

10. Tenon standards into feet (as per diagram Fig. I) and glue up.

11. Set out shoulder on cross rail and mortises on standards. Cut these and fit together.

12. Work cappings, clean up all pieces for stand. Fix cappings, and when dry cramp in cross rail, testing carefully for squareness before leaving to dry (see Fig. 2).

13. Set out stile and rails for glass frame (details as for a door frame illustrated on p. 35).

14. When the glass frame is dry, plane up square and clean up; $\frac{3}{16}$ in. each side to be allowed for screw movements.

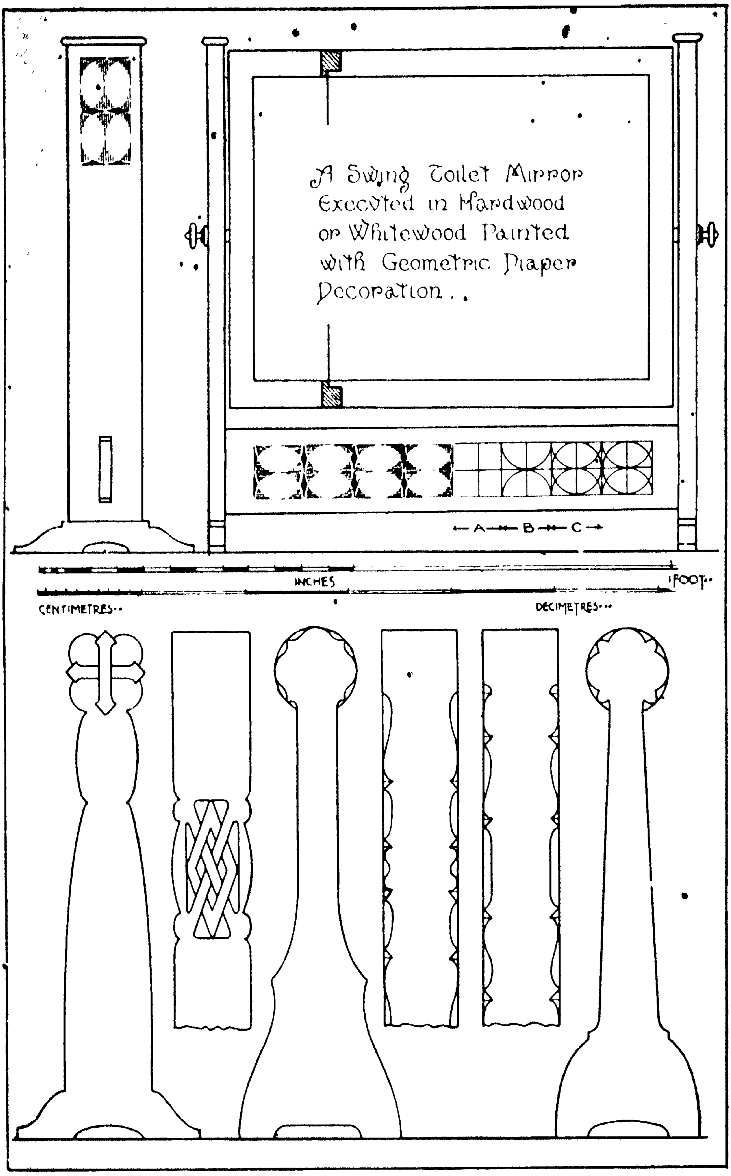

A Swing Toilet Mirror
Executed in Hardwood
or Whitewood Painted
with Geometric Diaper
Decoration . .
A
B
C
INCHES
1 FOOT
CENTIMETRES
DECIMETRES

FIG. 1.

15. Cut plates in stiles of frame and bore standards.

16. Fix glass in frame, as in diagram Fig. 2, by glueing blocks 1 in. long in the position shown. Complete by screwing on back as per section.

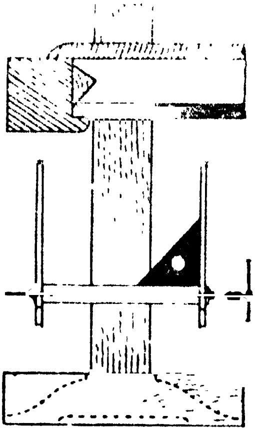


FIG. 2.

The Decoration of the complete specimen shown is based upon a simple geometrical pattern. This should be set out as shown in front elevation. Squares are first drawn, then each is divided into four parts (see A). Semicircles are then described (see B) and finally a circle in each original square touching the sides (refer to C). A simple diaper is thus formed, which should be coloured in with various paints and sable hair brushes. A similar procedure is followed for the standards.

Alternate Treatments for the standards and cross rail are also illustrated opposite. The first and second examples represent simple recessing forming strapwork, whilst the four last examples show variation of outline ornamented with easy chamfering.

AN UPHOLSTERED STOOL (Fig. 4).

Note.—The model is based upon stools of the Queen Anne period so far as general outline is concerned. The treatment of the under-railing is essentially modern. Turning for work of this character is best studied from old examples, the first and third examples are adapted from Queen Anne detail. The method of connecting the under-railing is described on p. 53 in connexion with occasional tables. Wainscot oak may be used for models of this type, but Italian walnut is preferable. Various methods of building up the turning are illustrated in the diagram Fig. 5 on p. 49.

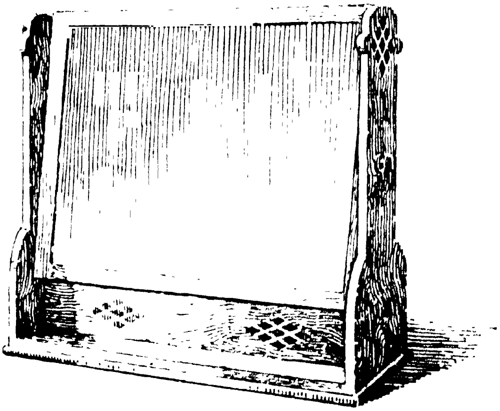


FIG. 3.—A swing toilet mirror.

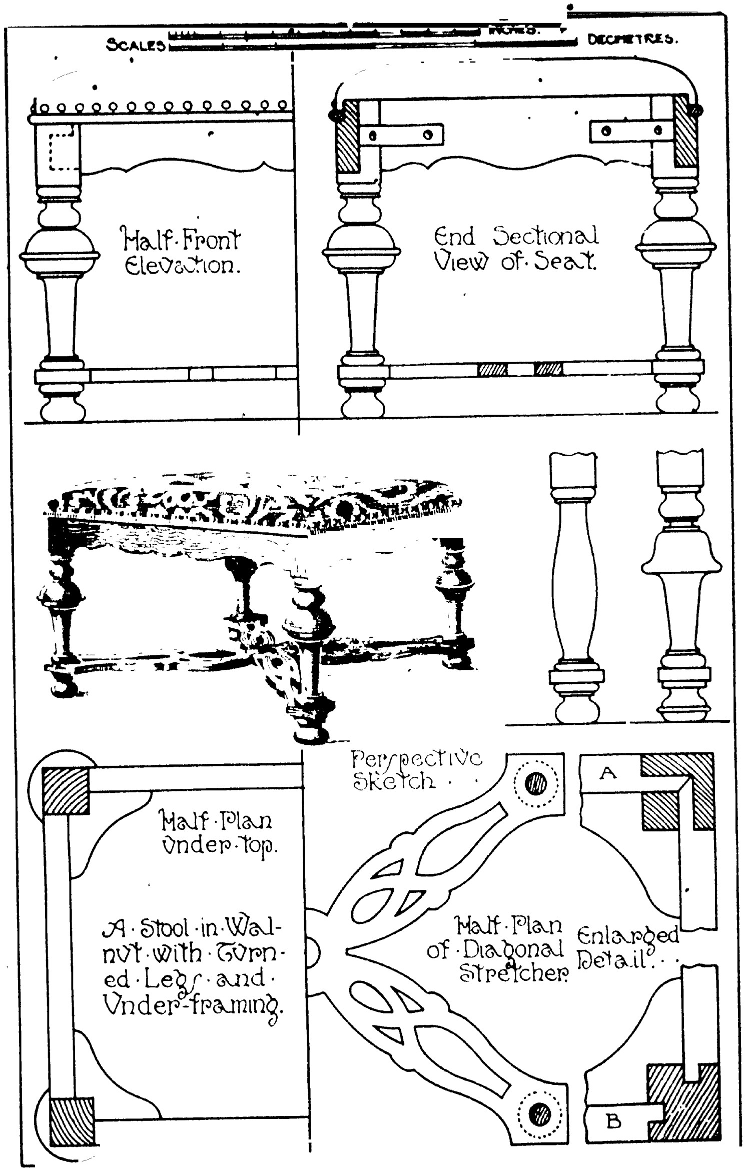

SCALES
INCHES.
DECIMETRES.
Half-Front Elevation.
End Sectional View of Seat.
Perspective Sketch
Half-Plan Under-Top.
A·Stool·in·Walnut·with·Turned·Legs·and·Under-framing.
Half-Plan of Diagonal Stretcher
Enlarged Detail
A
B

FIG. 4.—An upholstered stool of Queen Anne style.

The Process.—Saw out and plane up to width and thickness the following material:—

		English		*Metric.*
4 Legs		10½ in. × 2 × 2 in.	*It.* walnut	26 × 4·5 × 4·5 cm.
4 Feet		3½ in. × 2 × 2 in.	,,	8 × 4·5 × 4·5 cm.
2 Long Rails	1 ft.	7 in. × 2¾ × ⅞ in.		48 × 7 × 2·25 cm.
2 Short ,,	1 ft.	1¼ in. × 2¾ × ⅞ in.		34 × 7 × 2·25 cm.
2 Under ,,	2 ft.	2 in. × 3¼ × ⅝ in.		66 × 8 × 1·5 cm.
1 Moulding	6 ft.	3 in. × ¾ × ⅜ in.		190 × 1·75 × 1 cm.
For Brackets	1 ft.	8 in. × 4 × ⅞ in.	beech	51 × 10 × 2·25 cm.

1. Set out tenons on rails and mortises on legs, cut same. (Bare-faced tenon is employed, see detail A in sectional plan.)

2. Halve together the under rails, glue together and level off.

3. Execute turning on legs and glue up rails and legs.

4. Level off top, gauge for rebates (see sectional view), and execute same.

5. Set out with templet the shaping on under rails, cut same, and finish with files and glass paper, bore for pins.

6. Glue feet through rail into legs, clean up framing, and mitre moulding round rebate.

7. Cut and fix the angle brackets.

A, Fig. 5. Shows leg turned with groove to receive a separate bulb part, foot pinned through under-frame into leg.

B, Fig. 5. Shows an alternate design with similar constructive detail.

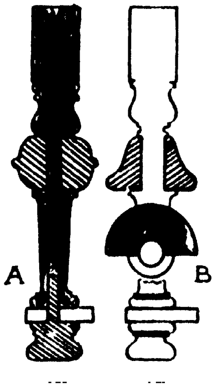


FIG. 5. Diagrams showing construction of turned legs.

STATIONERY CASE (Fig. 6).

Note.—An advanced model introducing secret mitred and lapped dovetailing in carcase, with decoration based upon veneer inlaid and incised, with vee tool cuts filled with wax composition.

The Process.—Cut out and plane up to thickness the following material:—

		English		*Metric*
Top	1 ft.	5¾ in. × 7 × ½ in.	oak	46 × 18 × 1·3 cm.
Bottom	1 ft.	5¾ in. × 6½ × ½ in.	,,	46 × 17 × 1·3 cm.
2 Ends	1 ft.	0¾ in. × 7 × ½ in.	,,	31·5 × 18 × 1·3 cm.
Back	1 ft.	5¼ in. × 12½ × 7/16 in.	,,	44·5 × 31 × 1 cm.
Front		10 in. × 11½ × 9/16 in.	,,	28 × 30 × 1·5 cm.
Clamps	1 ft.	0 in. × 3½ × 9/16 in.	,,	30 × 9 × 1·5 cm.
4 Feet		4¼ in. × 1¾ × ¼ in.	rosewood	11 × 5 × ·75 cm.

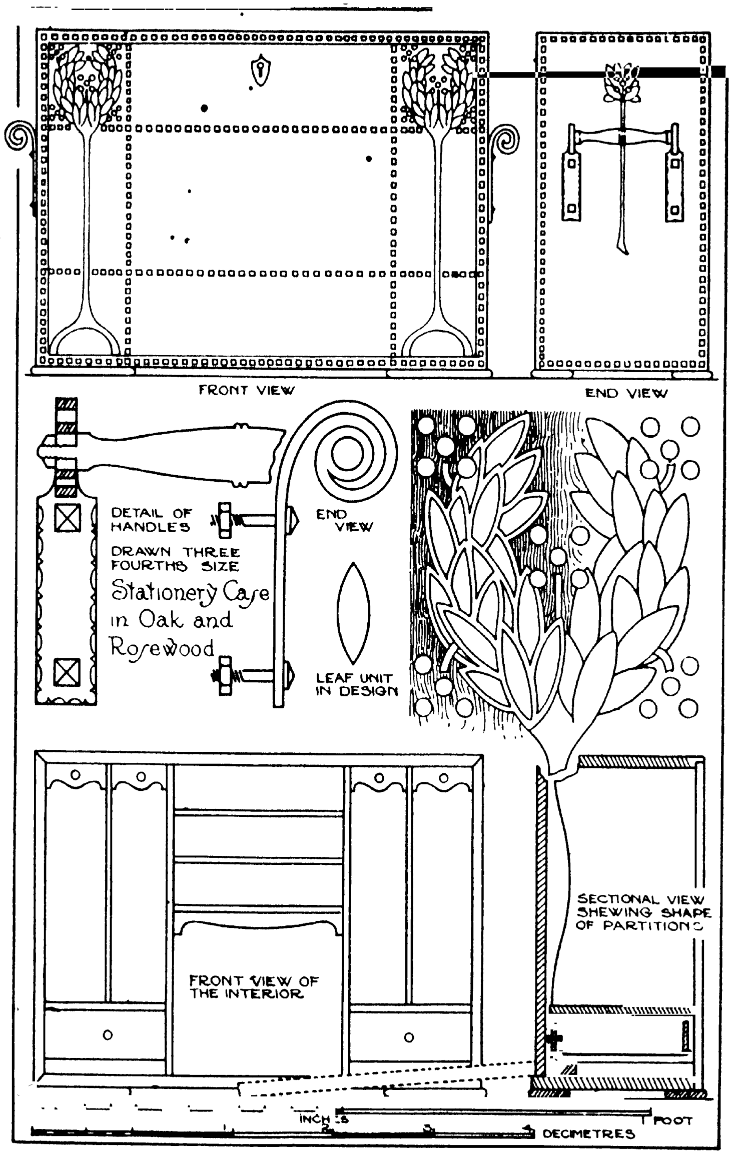

FRONT VIEW
END VIEW
DETAIL OF HANDLES
DRAWN THREE FOURTHS SIZE
Stationery Case in Oak and Rosewood
END VIEW
LEAF UNIT IN DESIGN
FRONT VIEW OF THE INTERIOR
SECTIONAL VIEW SHEWING SHAPE OF PARTITIONS
INCHES
FOOT
DECIMETRES

FIG. 6.

Interior.—

2 Vertical Divisions	1 ft. 0½ in. × 6 × ¼ in.	holly	31·5 × 15 × ·75 cm.
2 Central „	9¼ in. × 6 × ¼ in.	„	23·5 × 15 × ·75 cm.
3 „ Horizontal Divisions	7 in. × 6 × ¼ in.	„	18 × 15 × ·75 cm.
2 Side „ „	5¼ in. × 6 × ¼ in.	„	13·5 × 15 × ·75 cm.
4 Arches	2½ in. × 1 × ¼ in.	„	7 × 2·5 × ·75 cm.
1 Central Arch	7 in. × 1 × ¼ in.	„	18 × 2·5 × ·75 cm.

1. Plane up top, bottom, and ends to length and width

2. Set out mitred dovetail joints at corners per exercise following on A and B.

An Exercise in Mitred Dovetailing.

(*a*) Mark mitre lines as shown in Fig. 7

(*b*) Gauge lines across inside of both pieces.

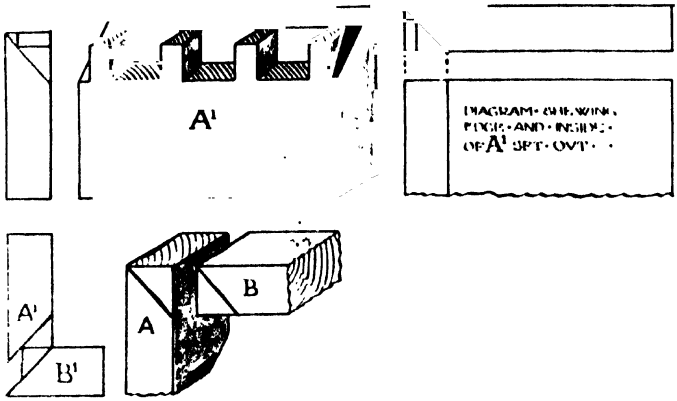


FIG. 7 Diagrams showing method of setting out, etc.

(*c*) Gauge and rebate lap

(*d*) Mark out pins on A′, cut same and remove waste.

(*e*) Place A′ on B′ in position shown, and with a marking awl mark position of sockets.

(*f*) Cut sockets and chisel out same, cut mitres and fit together.

3. Fit carcase together, take apart and rebate same to receive back.

4. Mark and cut the grooves in carcase to receive the interior divisions.

5. Clean up inside surfaces and glue together, fit and screw back in position.

6. Clamp together the front (tongue worked on centre part, fitting into grooves on clamps).

7. Glue together, level off when dry, and fit in opening.

8. Fit up the interior, all pieces are housed ⅛ in. deep into top divisions.

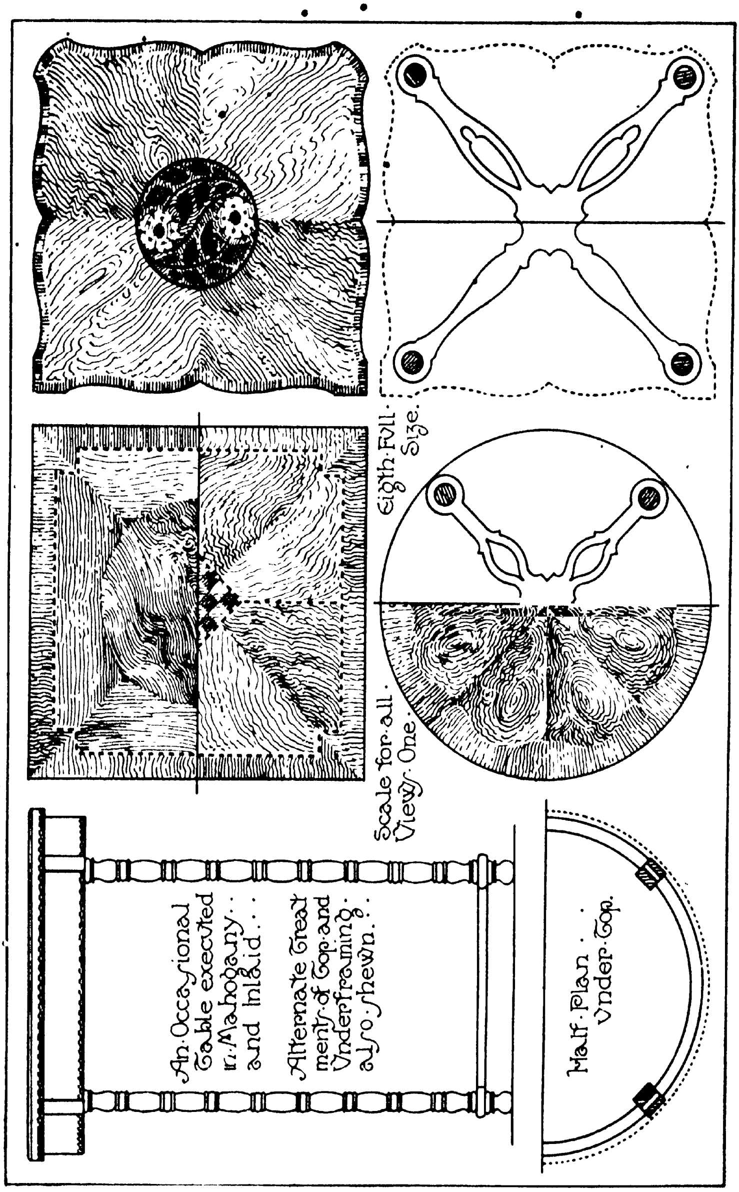

An·Occasional Table executed in·Mahogany and Inlaid.
Alternate Treatments·of Top·and Underframing also·shewn.
Scale·for·all·Views·One·Eigth·Full·Size.
Half·Plan Under·Top.

Fig. 8.

The Decoration.—Method of inlaying the mosaic stringing is described on p. 146. Veneers are used for the ornamental device; these should be cut to outline and inlaid level with the surface of the wood When dry the leaves are indicated or outlined with vee tool cuts, and filled with composition (see also p. 148); the spots are executed with a drill and filled in with composition The whole is then allowed to stand by and is then scraped and sandpapered. The inside of the fall should be lipped with veneer ¼ in wide, the groundwork covered with morocco leather or skiver

OCCASIONAL TABLES (Figs 10 and 11)

The Rim.—The elevation and plan shows a suitable treatment for this type of furniture, a half plan shows the method of forking the legs into the rim, a general constructive feature of circular and elliptical work When building up the rim, a board of ¾ in pine should first be planed up true, and the true shape of rim set out upon it This is divided into four parts, one of which is duplicated in ¼ in mahogany and constitutes the templet The templet is used to mark out twelve pieces or segments, four for each layer, and each segment can then be spokeshaved exactly to the templet size Next, one piece is fitted to the board and pinned in position, then the remaining three segments are fitted in and secured with pins, glueing the joints as one proceeds This completes one layer, which is then planed true and toothed, the next layer is spaced so that the joints fall midway between those of the bottom layer, usually called brickwork fashion. As these are fitted, they are glued down and pressure applied with handscrews. When dry this layer is also planed and toothed, and the third layer fitted in the same relative position as the first (see diagram below)

The Legs should be planed up perfectly square to size, then marked for turning A detail of the foot is shown in Fig. 8, from which it will be seen that the under-framing is secured by introducing a pinned foot which glues through the under-framing into the legs

The Under-framing should be prepared in the form of an X. One piece is mortised right through to receive two short rails (see diagram, Fig 2) tenoned into same. When this is fitted and glued together the design is traced to the wood, or as an alternative, a pattern of one-quarter the shape is cut in cardboard, the remaining three parts being marked from this.

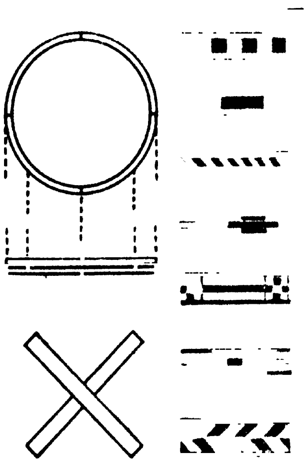


FIG. 9.—Plan and elevation of rim and various mosaic stringings.

The Top can either be cut from solid material and veneered on both sides or laminated, viz. five-ply material can be adopted, in which case it is only necessary to veneer the top side. The veneer of the circular top shown on p. 52 is intended to be of the curl variety; eight pieces are used to form the centre part. These should be secured between two thin V-shaped pieces of wood during the process of cutting, the curved edge is finished with a fine file and the V shape is planed They may then be separated and glued down to a sheet of damp stretched paper, the top is completed by fitting round the curved cross banding, glueing each segment down as they are fitted. The top is then veneered with this built-up work and the paper is removed with a toothing plane after the glue has dried. Cross banding on edge of top is best laid with a hammer.

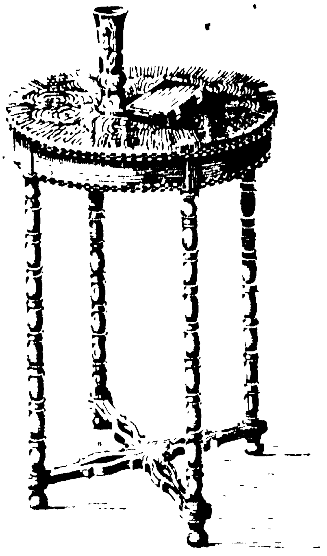


FIG. 10. Sketch of circular table.

Square Tables.—Various treatments are shown in Fig. 8 for the tops of square tables, the only different constructive feature of these types being the connexion of straight rails to the knee parts of legs. This is dealt with in reference to the table illustrated on p. 55 and described on p 56.

OCCASIONAL TABLE (Fig. 11).

Object.—A model to introduce simple general principles of table construction, the principles being similar to those necessary for hall, draught, chess, and writing tables, etc.

The Joints are all mortises and tenons, the "stubbed" type being utilized for the wide rails and connexion of under rails with the legs. In the case of the second example, showing two rails near the centre of the side-rails, small through mortises and tenons should be used, or the long rails can be shouldered and lap dovetailed into the short ones from underneath. The latter is very effective and prevents the shoulders opening; it has also the advantage of not showing the construction under ordinary circumstances.

The Process.—1. First saw out the wood, either mahogany or walnut, to the following sizes:—

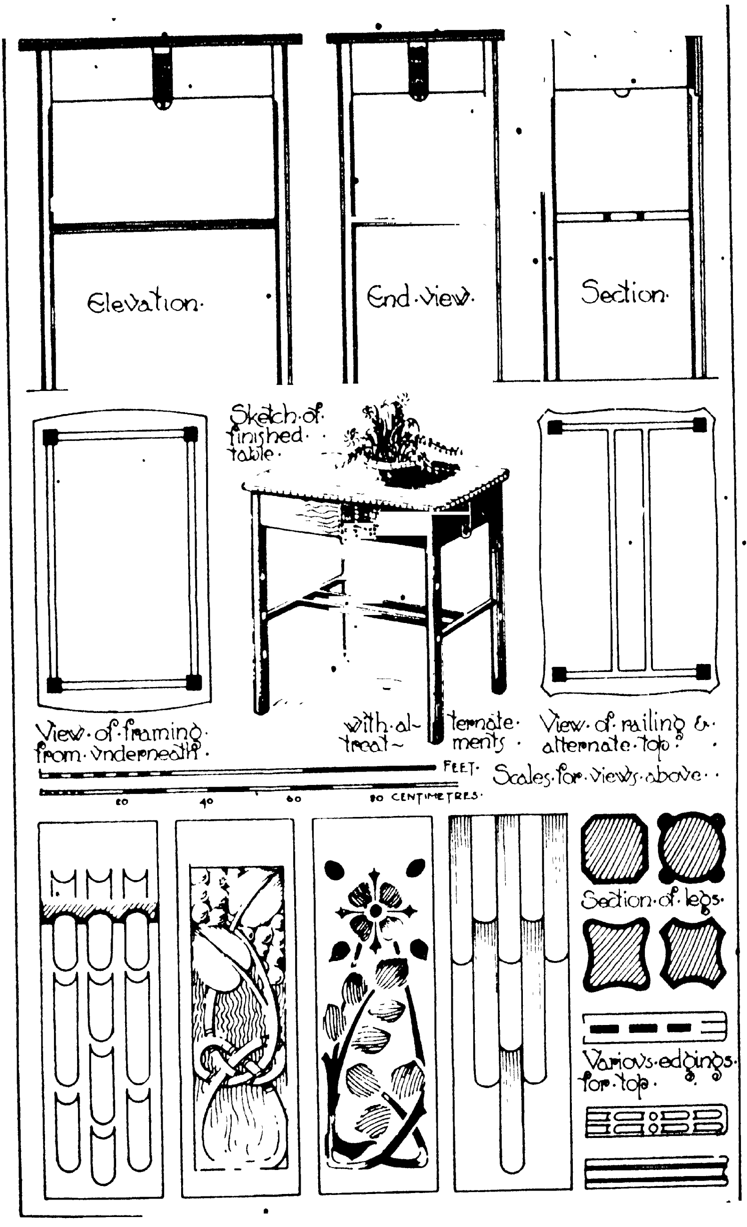


Fig. 11.—An occasional table.

	English.	*Metric.*
4 pieces legs	2 ft. 6 in. × 1⅜ × 1⅜ in.	79·5 × 3·5 × 3·5 cm.
2 long rails	1 ft. 10 in. × 4⅞ × ⅞ in.	58 × 12·5 × 2·2 cm.
2 short ,,	1 ft. 2 in × 4⅞ × ⅞ in	36·5 × 12·5 × 2·2 cm.
1 top	2 ft 2½ in. × 16½ × ⅝ in.	69 × 42·5 × 1·6 cm.
2 short bottom rails	1 ft. 1½ in. × ⅞ × ½ in.	35 × 2·2 × 1·3 cm.
2 long ,, ,,	1 ft. 9½ in × ⅞ × ½ in.	58·5 × 2·2 × 1·3 cm.
4 tablets	6 in × 1¾ × ⅜ in	16 × 4·4 × 1 cm.

2. Plane up all material on face, side, and face edge, then to thickness.

3. Gauge and plane legs, top, and bottom rails and tablets to width.

4. Square up top to required size, or cut to shape if curved.

5. Place the four legs together and handscrew same together, then square across all required lines, viz. total length, and top and bottom mortise lines.

6. Separate the legs and square lines on adjoining inside faces.

7. Place rails together, two top and two bottom rails in each set and set off shoulder lines.

8. Separate the pieces, and return shoulder lines on all wide faces, back and front. Then mark mortise and tenon lines on all pieces.

9. Cut out the mortise and saw the tenon lines and shoulders; fit two long sides together, and when adjusted satisfactorily, clean up all parts and glue up.

10. When the latter are dry fit up all short rails, clean up the various pieces and glue between the long sides. It should be measured on the diagonals of plan and elevation to ensure the whole being properly square.

11. Cut and glue in tablets, then saw off spare wood of legs at top and bottom and plane top side true. Prepare pockets for screwing through rails into top.

12. Shape and inlay top if required, clean up and fix by pocket screwing from inside the rails.

The Decoration.—Various treatments for the decoration of the tablet are shown. The first consists of simple gouge tooling. The second shows a design for carving, which would first be cut to outline and grounded out, then modelled on leaves, stem, berries, etc., with gouges. The third example shows inlaying in various woods, and the last an alternate arrangement of slips of mother of pearl, three in top row, two in the second, with a single terminal piece. This decoration is fairly simple, and very effective when used in combination with brown oak, American or Italian walnut.

Four details of moulded legs are shown. The introduction of either of these would involve more difficult construction; generally, the rails would have to be set farther back from the face sides, those below being spaced exactly in the centre of the moulded side. The chamfered example should be stopped just below the rail, as is shown in the elevations.

CHAPTER VI

FIRST YEAR MODELS (METAL)

ESCUTCHEONS

Their Use. Used to protect the keyholes cut in doors so that the holes do not get broken away by continually putting the key into the lock. When made with a cover they prevent dust getting into the lock

The Process.—1 To be cut out of 14 or 16 I S W G brass and outline filed to shape with bastard and smooth files.

2 Drill holes for screws and keyhole.

3 Trim off the burr and file keyhole to shape

4. Hold the escutcheon on a flat piece of wood by means of pins round the edges.

5 Face up with bastard and smooth files.

6 Chamfer where necessary, then add the decorative features.

7 Polish, stain, or lacquer, as required

The Decoration.—The top line on page 58 shows decoration by means of an outline of pleasing form.

The bottom line shows how chamfering may be used as a decorative feature, additional to the outline.

The top line on page 59 is where simple lines, dots, and curved chisel marks are utilized as decorative motifs.

The bottom line on the same page gives a more difficult example of piercing with a fret saw; the second one shows a simple form applied and fixed by small rivets, this form is also shown on page 67, the third one is a covered escutcheon. A pattern would be made of this cover, and a casting obtained, then filed up and riveted together, so that the weight of the cover would allow it to drop into its correct position after the key was removed from the lock.

With regard to setting out the keyhole, a line should be drawn down the centre of the escutcheon, and the centre dots for marking the holes to be drilled should be placed on this line. This keyhole could also be punched out, or cut out with a fret saw (see page 91 for fret saw and method of using it).

The decorative screw heads with one exception are ordinary screws filed to the shapes suggested. The last one with the row of pearling round the edge would be cast and the pearls chased up by hand

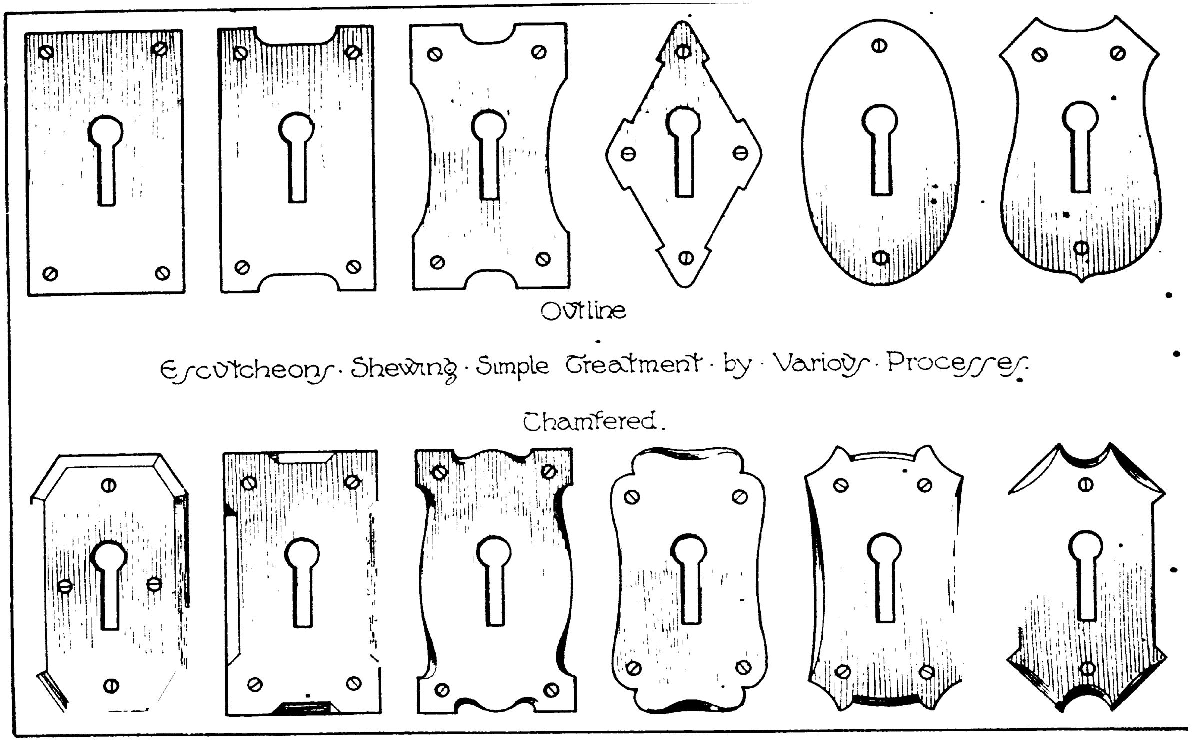

Outline
Escutcheons · Shewing · Simple Treatment · by · Various · Processes.
Chamfered.

FIG. 1.—Examples of simple escutcheons.

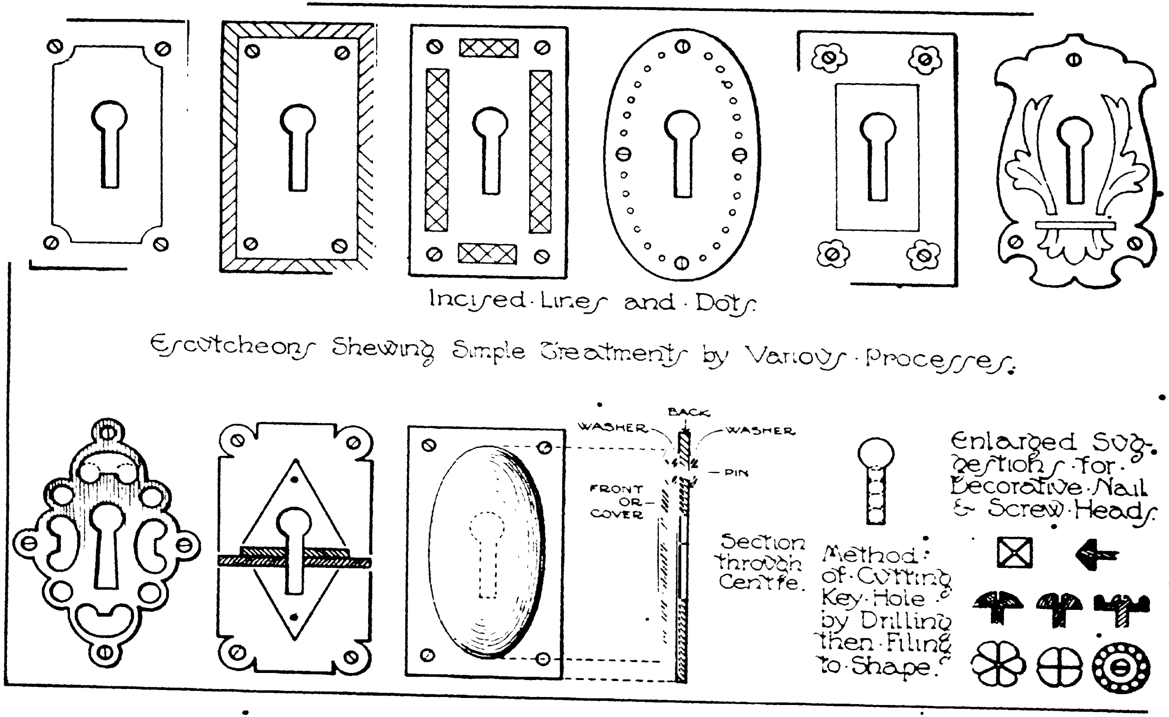
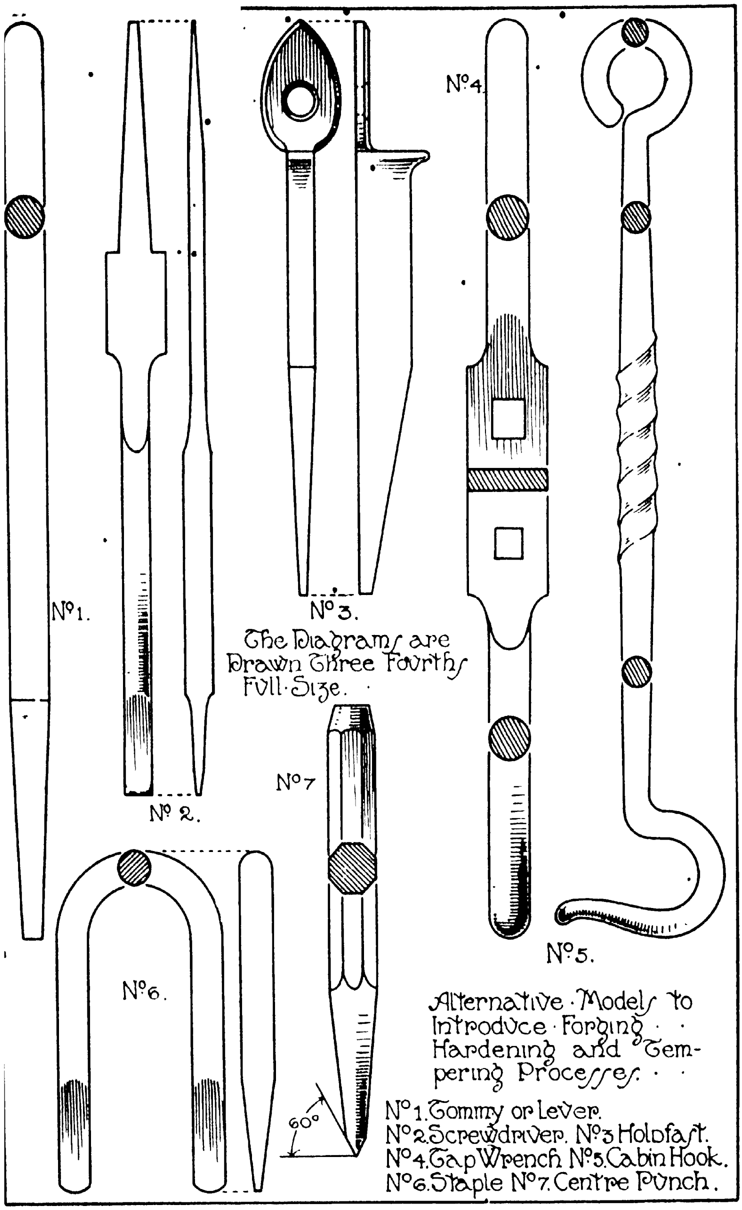

Incised · Lines and · Dots.
Escutcheons Shewing Simple Treatments by Various · Processes.
WASHER
BACK
WASHER
PIN
FRONT OR COVER
Section through Centre.
Method: of · Cutting Key · Hole: by Drilling then · Filing to · Shape.
Enlarged Suggestions · for · Decorative · Nail & Screw · Heads.

Fig. 2.—Examples of decorated escutcheons.



The Diagrams are Drawn Three Fourths Full Size.

Alternative Models to Introduce Forging Hardening and Tempering Processes.

No 1. Tommy or Lever.
No 2. Screwdriver. No 3 Holdfast.
No 4. Tap Wrench No 5. Cabin Hook.
No 6. Staple No 7. Centre Punch.

Special Features.—Although the escutcheon is taken as an example of how it is possible to add difficulty and a new tool operation in successive steps to a simple form, there are many other objects which can be treated in a similar manner.

METAL MODELS: TOOLS, ETC. (Fig 3).

Object and Uses. A collection of easy models suitable as exercises in forging. Their various names convey their uses

No. 1. **Tommy** or **Lever.**

This should be made from steel and not cut off until it has been drawn down. ⅜ in round tool steel about 2 ft 6 in. long, suitable for holding without the use of tongs, is a convenient size. Should be left from the hammer and not filed up.

No 2. **Screwdriver.** Made in the same way as No 1, but for spreading the wide part, a fuller, placed lengthwise down the rod, should be used ⅜ in square tool steel would be suitable Draw the round portion down first, then fuller out to width, cut off, and draw down tang Shape with hammer as much as possible, trim up with bastard and smooth files, finish off on emery bob, then harden and temper point to a dark brown

No. 3 **Holdfast.** This is a forging exercise, and a file should not be used on it.

Have a suitable piece of ½ in × ¼ in iron, heat to a welding heat and slightly up-set the end, then place end on anvil and flatten. Shape up with a set hammer and work up projecting piece (this is the difficult part), draw away and roughly point, and punch the hole while hot. Cut off, and finish, drawing down the point. If preferred the processes could be reversed, that is, the point drawn out first.

No 4 **Tap Wrench.**—According to the size of the holes required, so choose the iron Draw down and round up one end, repeat for other end, then cut off to length; round up ends and punch the holes, driving a parallel drift through to finish. Should not be touched with a file.

No. 5 **Cabin Hook.**—Use ⅜ in. square iron. Draw down and round the end, bend up the eye as shown on page 67, Fig 7, to the size required Cut off the length required, draw down and round end for hook Bend up the hook and cool out. Heat in centre and twist as shown on page 74

No 6. **Staple.**—Cut off to correct length, then draw down the ends and bend to shape. To make this a little more difficult, weld two pieces together and see that the weld comes in the middle of the bend, then draw out the ends and bend to shape while cold.

No. 7. **Centre Punch.**—This should be made from 5/16 in. square tool steel and drawn down to shape and cut off to the length required. Trim up with bastard and smooth files, harden and temper point to a dark brown This should not be put in the lathe to make the end circular, it should be done by hand.

The preceding models involve all the elementary forging exercises, and give good practice in the use of a hammer; the file should be used as little as possible.

The illustrations in Fig. 4 show the correct position to take when performing various operations. The position of the feet for instance in (1), (2), (3) being most important, for unless the operator is standing correctly the work cannot be done efficiently.

(1) Illustrates a piece of square iron being held in the tongs while the end is being upset or thickened. This operation frequently occurs in working iron, and it should be noticed that the tongs fit and grip the work so that it cannot slip. The same position applies when holding a bar of iron.

(2) This shows the position to be taken when bending iron. The fork fits into the square hole in the anvil and the operator is holding a scroll in the left hand and a scroll wrench in his right hand. By this means plenty of power is obtained, and a large amount of curved work can be done cold.

(3) This illustration shows the method of standing, and using a top and bottom swage and a sledge hammer. The operation being performed is "rounding up a tenon on a piece of ¾ in. square iron". It should be noticed that in using all kind of top tools, hot setts, etc., the top tool should be at right angles to the work.

(4) Shows the correct method of holding a hammer and chisel when chopping out. The usual fault in the use of a hammer is that it is not lifted up high enough to do its proper work. The reproduction shows the natural position assumed when the hammer is used by a skilled craftsman.

METAL MOUNTINGS FOR A CHEST.

Angle and Corner Plates

Object and Uses.—Used for the strengthening of chests and also form an ornamental feature. Introducing development of surfaces.

The Joints.—When the corner plates are bent up they form what is known as a "close joint".

The Process.—As a number of plates would be necessary to furnish a chest a template would be required. This could be made from some thin sheet metal, and should be arranged so that the bending lines could be scribed through.

1. These should be made from 16 or 14 I.S.W.G. metal. Lay the templet on and hold with a hand vice and mark round it with a scriber.
2. Cut out to shape, either chisel or saw pierce.
3. Punch or drill holes for screws and punch or engrave ornament.
4. Anneal so that material is soft, and dress up.
5. Bend up to shape and test with a set square.
6. Polish and lacquer if necessary.

The Decoration is either by punched holes, raised ornaments of simple form, piercing, and engraved lines which can be done with a chisel, a graver, or a tracer.

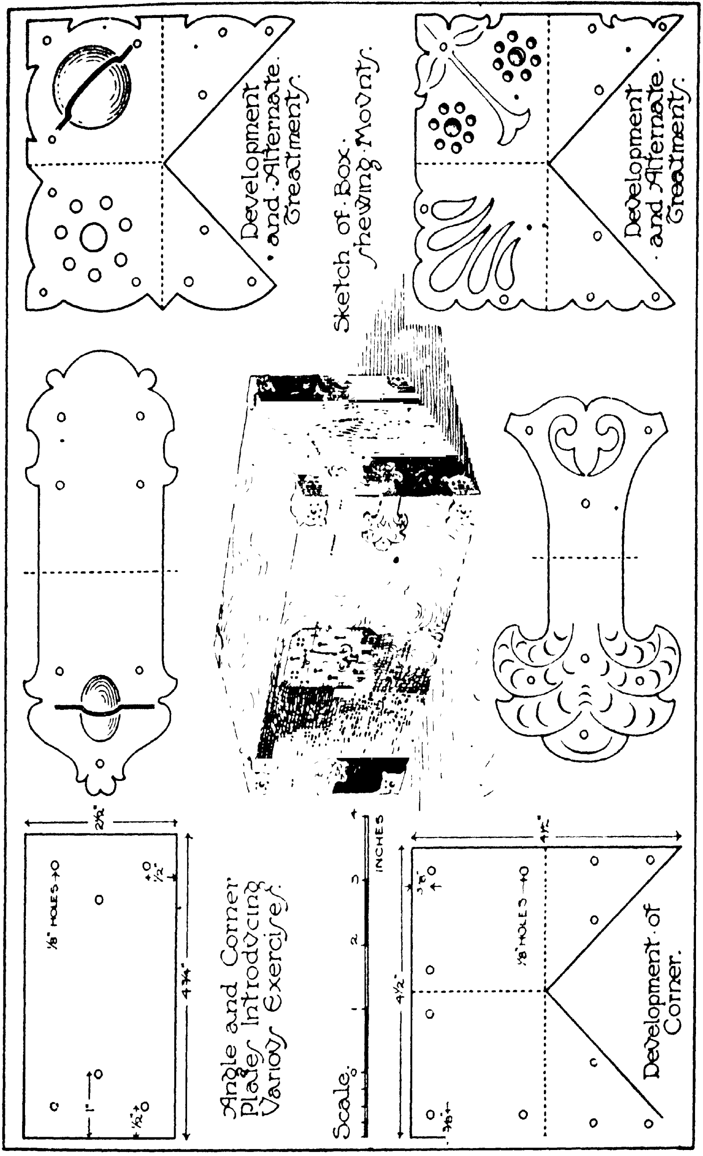

Development and Alternate Treatments.
Development and Alternate Treatments.
Sketch of Box shewing Mounts.
Angle and Corner Plates Introducing Various Exercises.
Scale. INCHES 1 2 3
Development of Corner.
2½"
4¾"
⅛" HOLES
1"
½"
4½"
⅛" HOLES
⅜"

FIG. 5.—Suggestions for straps, angle plates, or corner plates also development.

Special Features. A very simple model which gives good practice in simple setting out and development of surfaces. If only one was being made, a templet would not be necessary, but the whole thing could be set right out on to the metal. This model admits of many variations

A SCHEME OF WORK. METAL APPLIANCES.

Object and Uses. A course of graduated models; introducing many processes and arranged in order of difficulty

The Joints. The methods of joining metals involved in the various models are as follows Nos. 3 and 4 riveted joints; No 8 plain lap and soft-soldered joints, No. 10 brazed lap joint, No 11 tenoned and riveted, halved and riveted joints; No. 12 butt and clipped joint.

The Processes. No 1. A **Grinding Gauge.** Is used for testing the angles of tools, 110° and 60° for drills, 60 for chisels and centre punches, 70° and 80° for turning tools.

It should be made as follows: Use No 12 I S W.G iron; mark out with a brass scriber, cut out with a chisel, leaving the lines just showing, file down to the lines, using bastard files. Test with try square, protractor, and bevel, or with a bevel protractor. Face up on both sides with bastard and smooth files Centre punch and drill hole, fine finish face and edges with emery cloth held or glued on a flat piece of wood Lay gauge on a polished iron surface and punch figures to indicate size of angle with figure punches.

No. 2 A **Diamond-pointed Drill.**—Draw out, cut off to length, file up to shape, harden and temper to a dark brown; grind cutting edges up on grindstone

No. 3. **Outside Calipers.**—

1 Make a drawing of the calipers to the size required

2 Make a tracing of one leg and transfer to a piece of thin metal for a templet by means of carbon paper, or chalking the back of the tracing, laying on the metal, and going over the lines with a bone point.

3. Go over the lines on the metal with a scriber

4 Centre punch the centre of joint and describe the circle with compasses, then cut out the templet, working to the drawing as accurately as possible.

5. Mark out with a brass scriber on No. 12 I.S.W.G. iron the two legs, using the templet just made.

6. Cut out with a chisel, leaving the line in.

7. Drill a small hole in the centre of each joint of the legs and slip them on a pin.

8. File up both legs while they are together on the pin.

9. Flatten the legs and face them up both sides with bastard and smooth files.

10. If right sized washers cannot be obtained make them from the same material as that used for the legs.

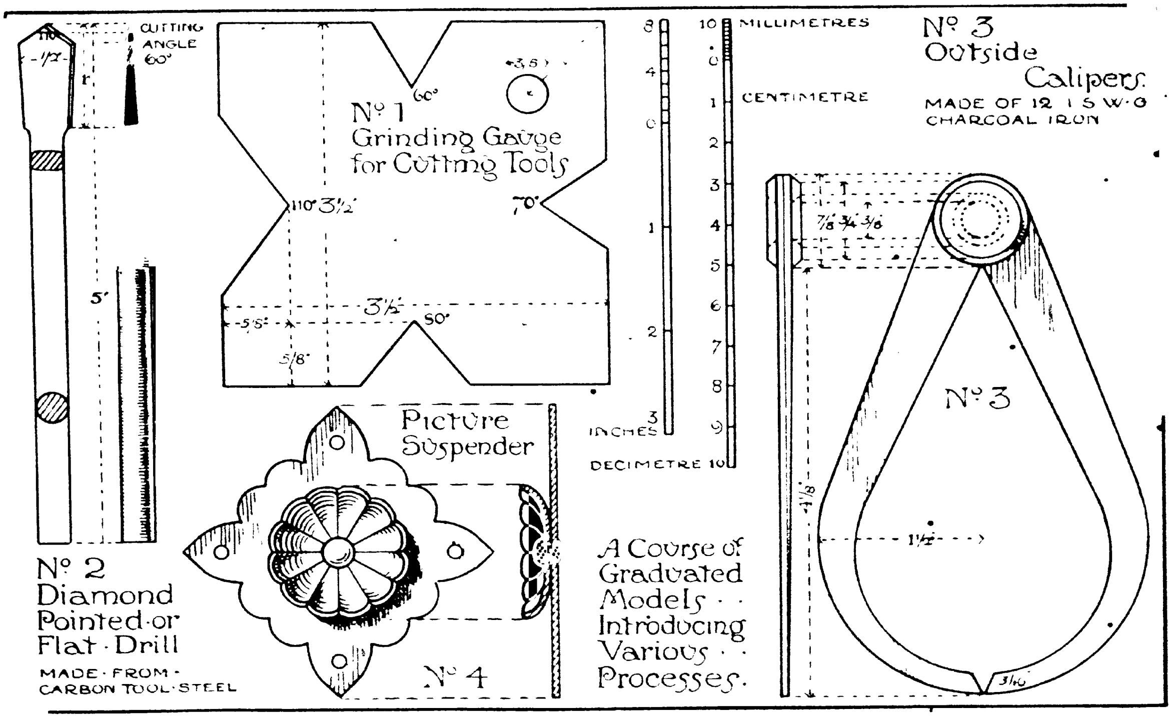

No 1
Grinding Gauge for Cutting Tools
60°
70°
110°
50°
3½
3½
5/8
3.5
5.5
No 2
Diamond Pointed or Flat Drill
MADE FROM CARBON TOOL STEEL
CUTTING ANGLE 60°
1/2
110
r
5
No 3
Outside Calipers
MADE OF 12 I.S.W.G. CHARCOAL IRON
No 3
7/8 3/4 3/8
1½
4⅛
3/16
No 4
Picture Suspender
MILLIMETRES
CENTIMETRE
DECIMETRE 10
INCHES
A Course of Graduated Models Introducing Various Processes.

FIG. 6.—A suggested course of models.

Fig. 6, *No.* 3 (*continued*).

11. Cut off a piece of ⅜ in. round iron for the rivet, square the ends and anneal it.

12. Drill the holes in the legs, and the washers to fit the rivet, and countersink the holes on the sides that will be outwards.

13. Put rivet in position and burr over with a light hammer completely filling the countersinking.

14. Face off the outside of rivets and fine finish the calipers with emery cloth.

No. 4. **Picture Suspender.**—The back should be made from 16 I.S.W.G. and the rose from 18 or 20 I.S.W.G. metal. The fluting of the rose could be left out if necessary.

1. Make templets for back and rose.
2. Mark out the back, using templet.
3. Cut out and file up to shape.
4. Mark rose out on metal, place on the pitch, and work it up from the back and front with punches.
5. Cut rose out and drill holes in back and rose, and anneal the rivet.
6. Polish, stain, and lacquer as required, including the rivet.
7. Rivet together by placing rivet in a hollow tool which is held in the vice.

Fig. 7, No. 1. **Cold Hand Chisel.**—Should be made from hexagonal tool steel.

1. Take a convenient length of steel and draw out the point.
2. Cut off to length.
3. Trim up the end, and file cutting edge to correct angle, using the grinding gauge.
4. Harden and temper cutting end to a dark brown.
5. Finish off on emery bob.

No. 2. **Finger Plate.** Could be made from 12, 14, or 16 I.S.W.G. material.

1. Cut off the material to the correct size.
2. Engrave the line, face up, then go over line again.
3. Set out the ornamental top, raise it on a lead block, cut it out, drill the holes.
4. Fit ornamental top to the plate mark off the holes and drill the plate, slightly countersinking the holes at the back, drill fixing holes.
5. Polish, colour, or lacquer as required.
6. Put top on to plate , put rivets in, one at a time, holding rivets in cup tool and lightly burring over at the back.

No. 3. **Steel Scriber.**—Should be made from ¼ in. square tool steel.

1. Cut off material and draw down both ends as shown in Fig. 2.
2. Cut off to correct length. Bend one end at right angles (Fig. 3).
3. Make eye, Figs. 4 and 5.
4. Twist centre as shown in Fig. 2, p. 74.

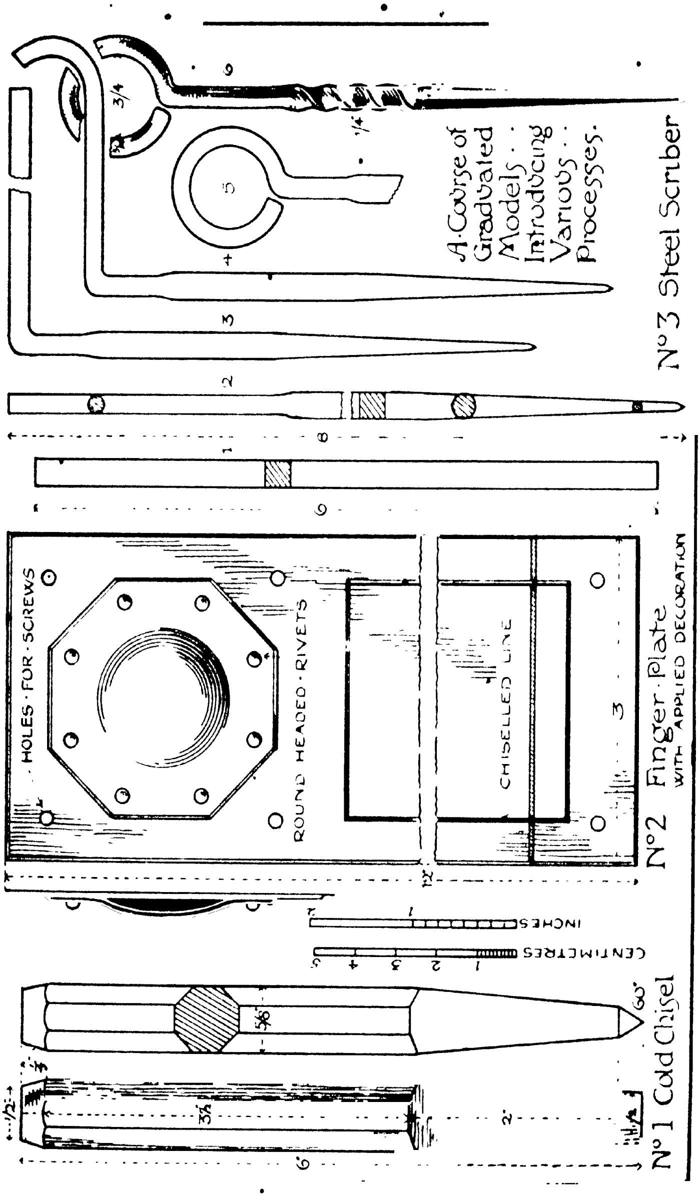


FIG. 7.—A suggested course of models.

5. Clean up, harden and temper point to a dark brown, if for use on soft metals to a light brown.

Fig 8, No. 1. **A Rectangular Box.** No. 22, 24, 26, 28 I.S.W.G. sheet metal should be used for this.

1. Set out the development of the body and the lid on the metal.
2. Cut them out clean with the shears.
3. Bend up to shape, using a folding machine, bending clamps, or a hatchet stake.
4. Tack the bottom part in a few places with solder and soldering iron, examine it for squareness, etc., then solder the seams neatly together.
5. See the lid fits true, then solder the seams neatly.
6. Wash well in potash and hot water and dry out in sawdust.
7. Polish if required.

No. 2. **A Pin Cutter.**—Size of material to be used depends on the size of the cutter; the one illustrated could be made from ⅜ in. square tool steel

1. Spread end for cutter with top fuller.
2. Round the shank and cut off to length.
3. Draw down the taper square
4. File the cutting end to the correct shape.
5. Harden and temper the cutting end to a dark brown.
6. Finish cutting end on grindstone and gloss up on emery bob.

Fig. 9, No. 1 **A Corner Clamp.** No. 18 I.S.W.G. metal would be suitable for this

1. Set out development on metal.
2. Punch the holes.
3. Cut out to shape.
4. Bend to correct angles, and see the corners where they overlap lie close together.
5. Braze the corner and clean off with a file.
6. Finish as required.

No. 2. **An Iron Grille.**—Used for protecting windows.

1. Make a drawing to the size required.
2. Cut off all the material a little longer than is actually required.
3. Make the frame by setting out all the necessary holes and drilling them.
4. Make the tenons on the various bars by sawing down and filing, and fit them tightly to the holes, seeing that the shoulders come up square. Check sizes.
5. Twist the centre bars. Note, two right handed and one left handed.
6. Mark off and make the halved joints, see they fit together neatly.
7. Drill the holes in the halved joints for the rivets, anneal them, and rivet all centre part together.
8. Put on the frame, riveting corners up first.
9. Rivet up other tenons, and trim off excess metal.

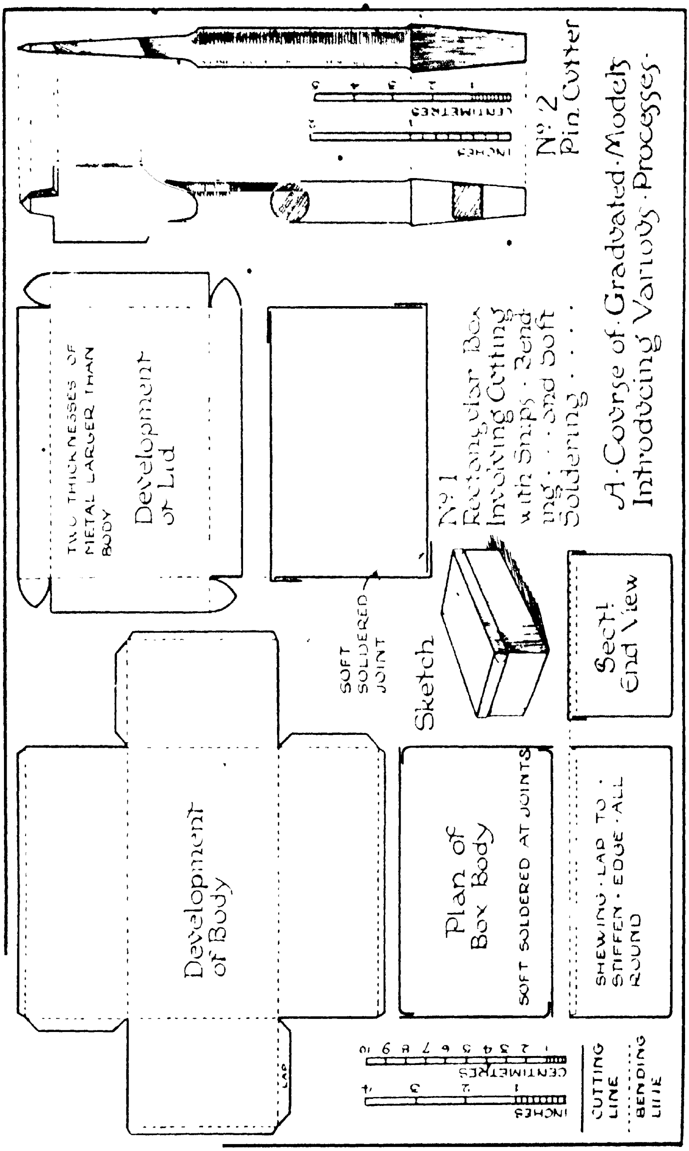


FIG. 8.—A suggested course of models.

Fig. 9, *No.* 2 (*continued*).

10. Coat with boiled oil which should be applied boiling hot.

11. Paint the colour desired.

No. 3. A Ring Drop Handle.

1. Make a drawing to the required shape and size.

2. Make templet of back-plate.

3. For the handle shown ¼ in. round for the ring and No. 14 I S.W.G. for the back-plate would be suitable.

4. Raise centre of back-plate, punch slot hole for the clip, then cut out to shape, marking this off the templet

5 Bend up ring, file the pin, and make the clip as illustrated on p. 74

6. Fit clip and ring to slot-hole, and see that it hangs square and at an equal distance from the back-plate

7. Drill screw holes, in back-plate and smooth it up if necessary.

8. Chamfer back-plate.

9. Polish, colour, and lacquer back-plate and ring.

10. Put together, and tightly bend over the clip.

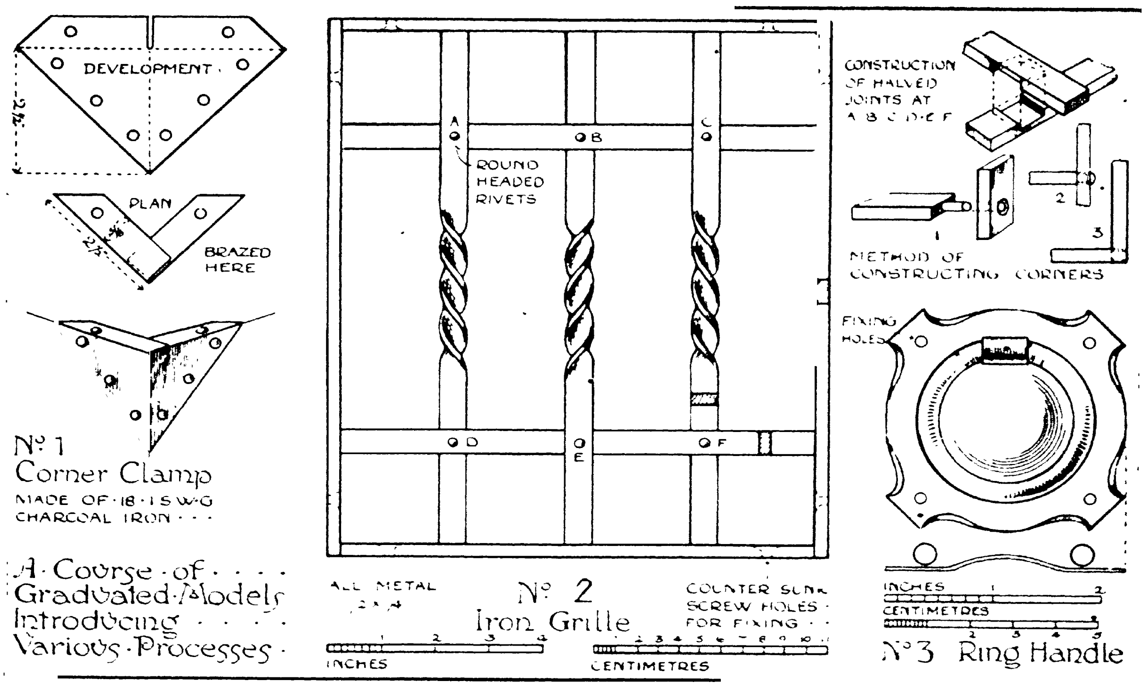


FIG. 9—A suggested course of models.

CHAPTER VII

SECOND YEAR MODELS (METAL)

Drawer Handles.—Fig 1. These are most suitable if made in iron and finished armour bright.

The Process.—The back plate should now be made first from 14 or 16 I.S.W.G. metal, and the rectangular hole punched for the reception of the clip The ring made next by the methods illustrated in Fig. 2

The ring should now be cut and sprung together, and the pin filed ready for the clip

The handle could now be laid on the back plate and the holes for screws marked and drilled.

The clip should now be made from 16 or 18 I S W G. metal, as illustrated in Fig. 2, and bent round the pin.

The handle and back-plate should now be polished and lacquered, then put together and the clip clinched.

Note.—The screws should come underneath the handle when it is hanging down, but of course the position of screw holes is frequently governed by the place where the handle is to be fixed

The Decoration.—There is practically no limit to the methods that could be adopted for the decoration of the handle and plate, but the designs shown are easily executed and are very effective, though they are obtained by the use of quite elementary tools. The back-plate could be, if preferred, marked all over with a hammer or punch, so obtaining a kind of texture.

Special Features.—These are the bending and twisting of metals, either in the hot or cold state, and a small amount of fitting

IRON GRILLES (Fig. 3).

Uses.—For protecting small windows. These provide excellent practice in bending and riveting.

Joints.—Halved, tenoned, and riveted.

The Processes consist of making a full-size drawing on strong paper, for the work to be laid on while working it into shape ; the frame must be made first of all in the manner illustrated in Fig 3, but not riveted together. The interior work is then bent to shape ; this can be done cold, leaving the ends an inch longer than necessary. The corners should be heated to bend them, and the cross-overs filed to fit neatly together. The frame should now be put together temporarily, and the interior work laid on the frame, and the tenons marked. The tenons

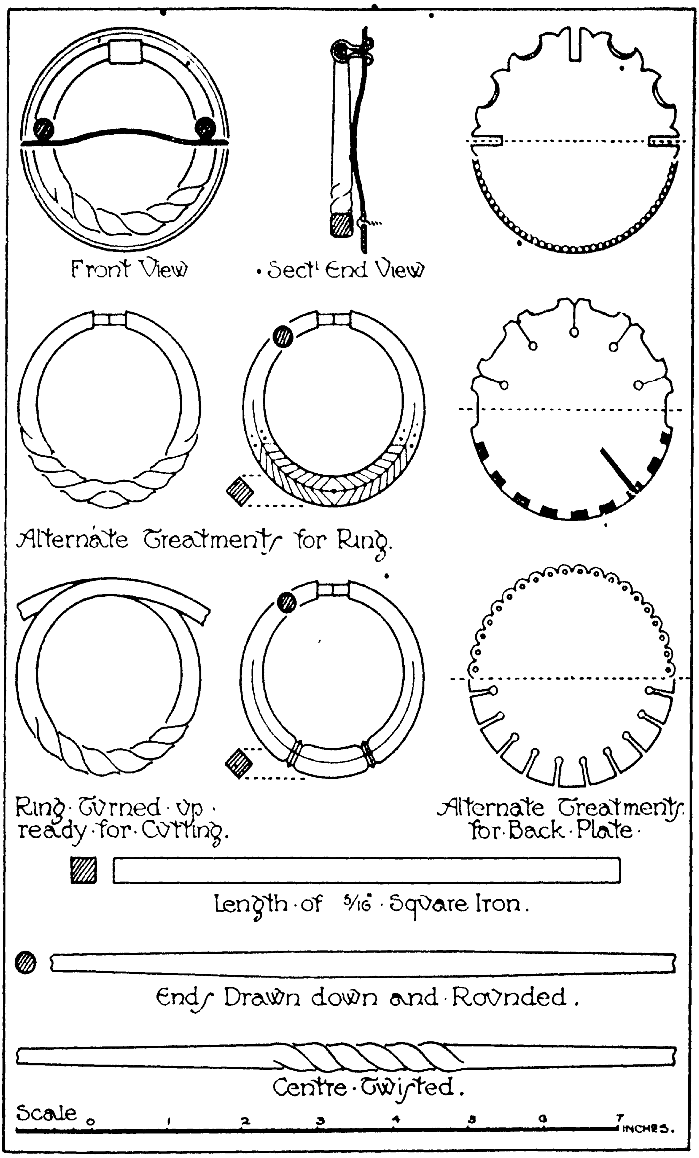

Front View
Sect^l End View
Alternate Treatments for Ring.
Ring Turned up ready for Cutting.
Alternate Treatments for Back Plate
Length of 5/16" Square Iron.
Ends Drawn down and Rounded.
Centre Twisted.
Scale 0 1 2 3 4 5 6 7 INCHES.

FIG. 1.—Suggestions for handles and their development.

should now be made, the whole thing put together, and the corners of the frame riveted together, then the other parts riveted to the frame. The grille could now be painted. Fig. 2 on plate facing page 63 shows the method for bending iron, cold or hot.

The Decoration.—This consists of straight lines, curved lines, geometrical designs, etc., according to the skill of the craftsman who is going to make it.

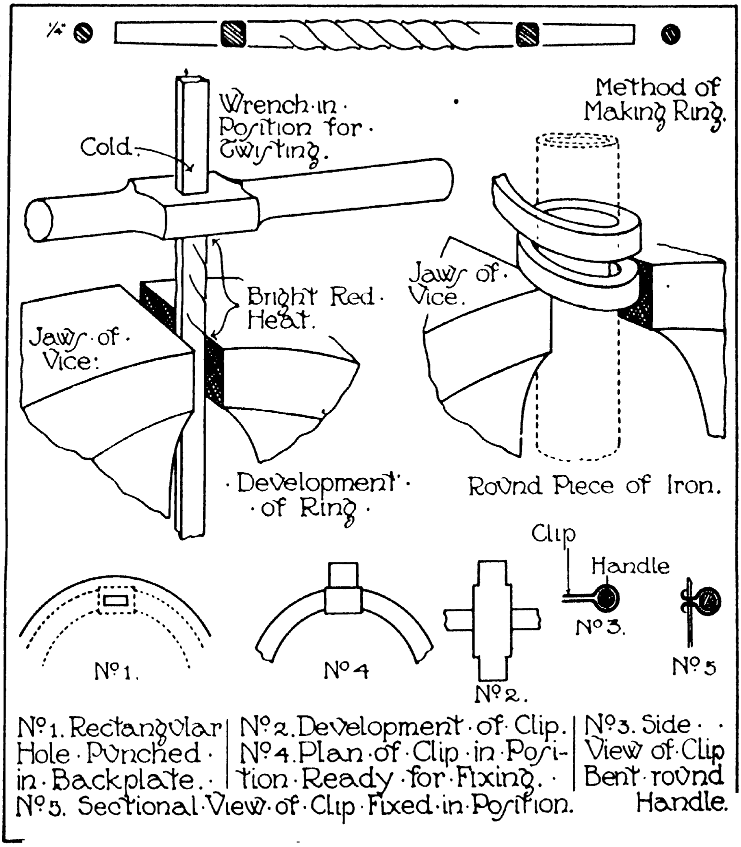

¼"
Wrench in Position for Twisting.
Cold.
Bright Red Heat.
Jaws of Vice:
Method of Making Ring.
Jaws of Vice.
Development of Ring
Round Piece of Iron.
Clip
Handle
No 3.
No 5
No 1.
No 4
No 2.
No 1. Rectangular Hole Punched in Backplate.
No 2. Development of Clip.
No 4. Plan of Clip in Position Ready for Fixing.
No 3. Side View of Clip Bent round Handle.
No 5. Sectional View of Clip Fixed in Position.

FIG. 2.—Processes in making a handle.

Also twisting the metal, using metal of different thicknesses and sections, all adds to the variety.

Special Features of these grilles are the bending and fitting. It is also good practice for simple designing and drawing of easy forms. For one method of bending see Fig. 2 on plate facing page 63.

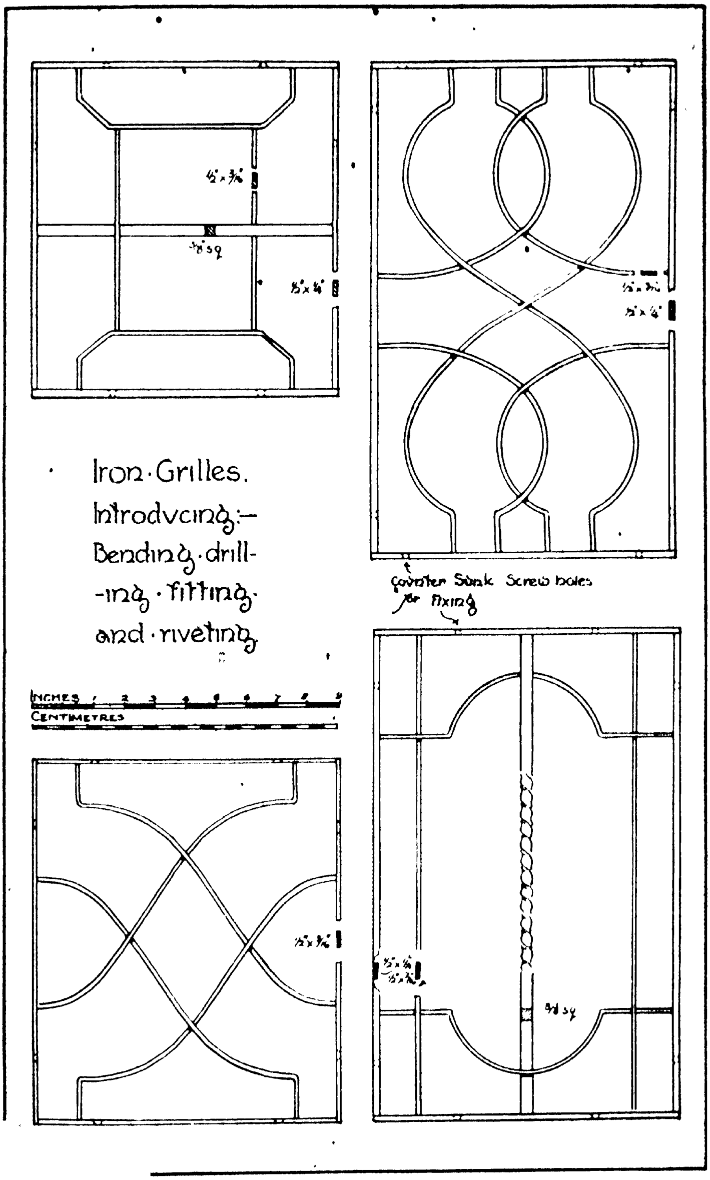


Fig. 3.—Suggestions for grilles.

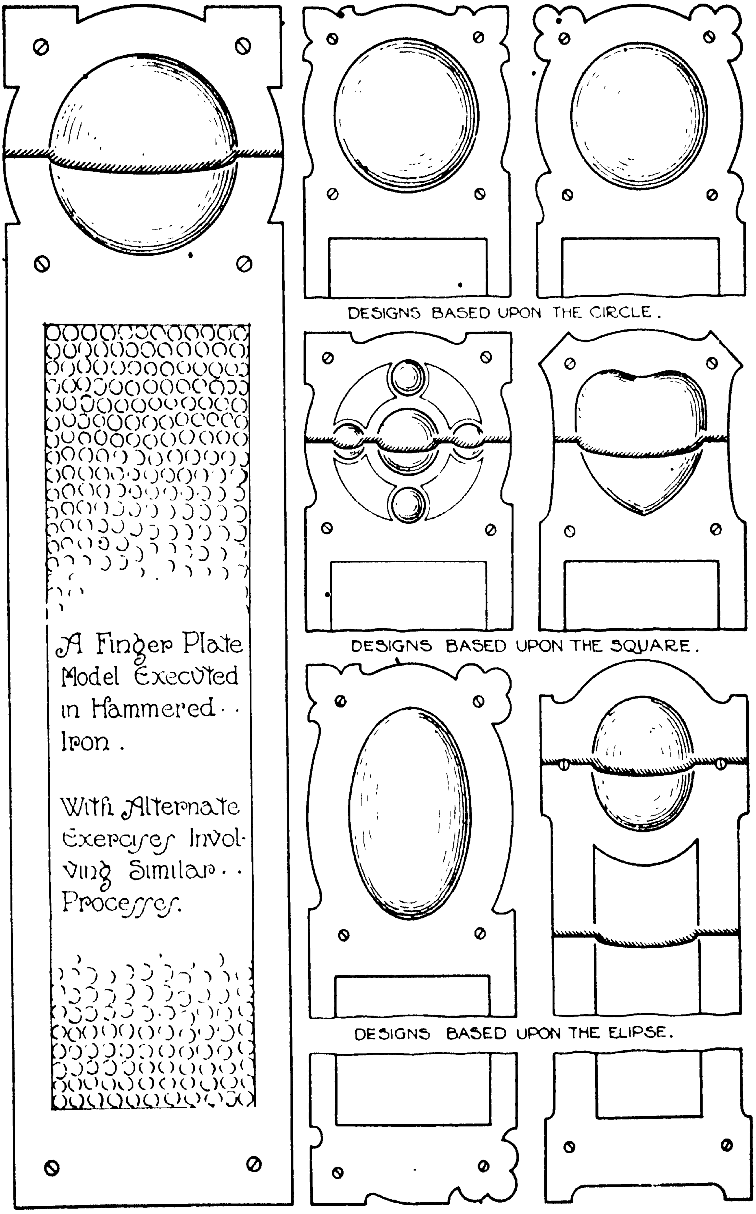

A Finger Plate Model Executed in Hammered Iron.
With Alternate Exercises Involving Similar Processes.
DESIGNS BASED UPON THE CIRCLE.
DESIGNS BASED UPON THE SQUARE.
DESIGNS BASED UPON THE ELIPSE.

FIG. 4.—Some suggestions for finger plates.

FINGER PLATES (Fig 4).

Object and Use.—Finger plates are used for fixing on doors so that the paint is not disfigured by handling, also to form decorative features

The Process. These should be made from 18 or 16 I S.W.G metal, leaving ¼ in. of metal extra all round

1 The design should be drawn on the metal

2. Raise with punches on a lead block, or a shaped hammer. They could also be stuck on a block of pitch and raised with chasing punches, working from the back and dressing down on the front

3 Put line in by tracing, or with a chisel, and where required hammer mark either with the ball pane of a hammer or a punch.

4. Cut out the plate to the shape drawn by means of a fret saw or with various shaped chisels.

5. Trim up the edges with a file and nicely flatten

6. Drill the holes for fixing. Know the size of the screw before drilling the hole

7. Polish and lacquer, or bronze if required

The Decoration is obtained by very simple means, namely, shaped outline, raised surfaces of simple forms, and engraved or chiselled lines.

Finger Plates Based on historical styles and suitable for more advanced students (Fig. 5, overleaf)

The Processes are all similar for the Tudor, German, Celtic, and modern examples —

1 The design is first drawn on to the metal and scribed in.

2 The metal is stuck on the pitch block

3 The ornament is raised from the back, the plate removed from the pitch, cleaned, and stuck on the pitch again, face uppermost.

4. The modelling is now dressed down from the front, care being taken not to use sharp tools or to leave rough tool marks

5. The plate should now be nicely flattened, cut out to the correct size and shape, and the holes drilled

6. Final dressing up and flattening.

7. Clean up, polish, colour, and lacquer

The Tudor plate should be made from No. 22 I S W G

The German plates should be made from No 18 or 16 I S W.G.

The modern plate from No. 18, 20, or 22 I S W.G.

The Celtic plate from No 22 I S.W.G.

The Oriental plate from No. 14 or 16 I S.W G

The Elizabethan plate from No. 14 or 12 I S.W.G.

The Oriental and Elizabethan plates are cut out with a chisel and then filed up After having been filed up the Elizabethan plate should have the face and chamfers finished by hammering, but do not put a number of honeycomb marks like pits in it, as this spoils the effect. Examine the effect as shown in Fig 9, No 1, Ch. XII; this is obtained by judicious hammering.

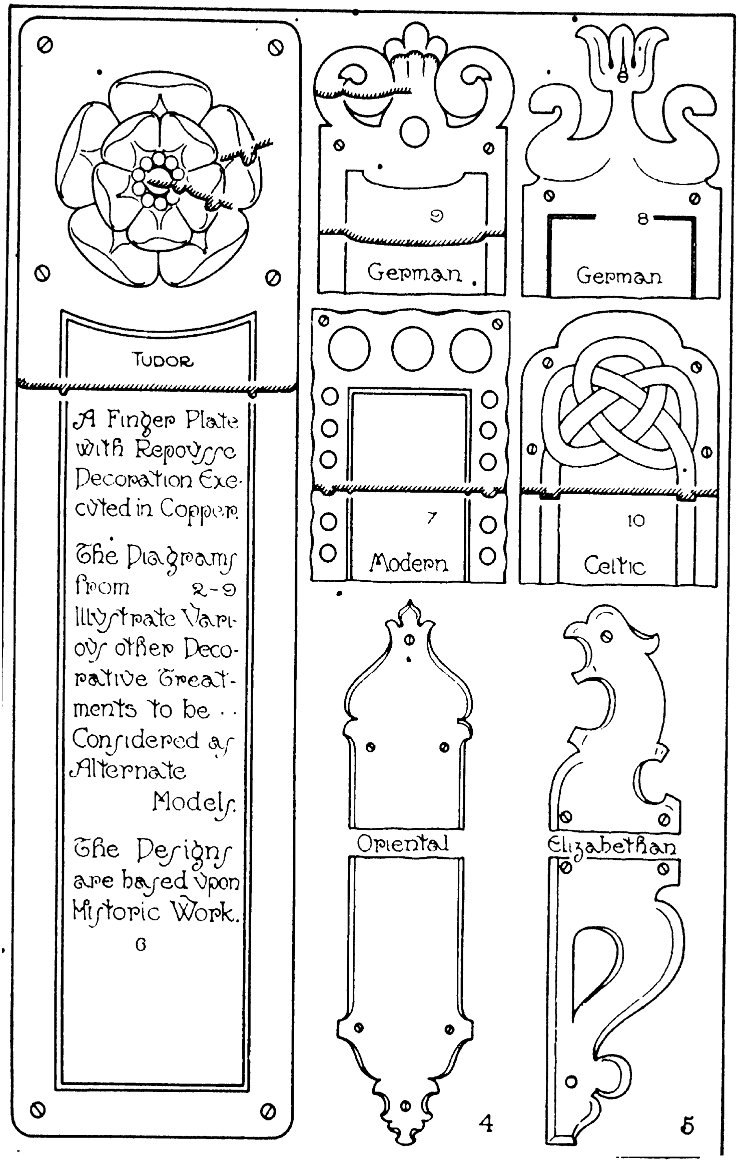


FIG. 5.—Finger plates based on historical styles.

TURNED WORK.

Object and Uses.—In Fig. 6 there are drawn a number of objects suitable for elementary exercises in turning and allied operations. They comprise a **Main** or **Master Chuck,** for fitting to the nose-piece of a lathe headstock, an **Auxiliary Chuck,** for screwing on to the master chuck. There are usually a number of these small chucks, which are all fitted to the master chuck, ready to be fitted to any job that comes along. The next drawing shows a **Loose Centre,** which is fitted into the sliding barrel of the tailstock, or in a carrier chuck; this should be made of steel, hardened and tempered. The next drawing is of a **Drilling Plug** which is also fitted to the tailstock. This is used for holding circular objects while they are being worked on or drilled, and it is an excellent model, introducing taper turning, taper fitting, sawing, and accurate filing. The next is a **Hammer Head,** which is a more difficult exercise, and involves turning by hand as well as with the aid of a slide rest, difficult drilling, filing, and hardening and tempering. The next is a **Balanced Handle** or **Swape.** This involves turning as above, drilling and tapping a stopped hole, screwing and fitting, and making a true square hole.

There are also the patterns to be made, and these should be of boxwood. This is more simple turning and patternmaking, but the easiest pattern to turn is the auxiliary chuck.

The Joints.—The two projecting lugs on the wood pattern of the master chuck are simple dowelled joints; all the chucks are screwed joints, and the loose centre and the drilling plug are taper fitting or friction joints.

The Processes for the main or master chuck:—

1. Turn the pattern from a piece of hardwood, turn and fit the studs, and glue them in.

2. Cast the chucks in brass or gunmetal.

3. Pickle it to loosen the sand.

4. Turn it out to size for the female thread, face it, screw it, and cut away the first thread as shown by dotted line. Take care that it fits the nose-piece of lathe without any shake, and that it does not wobble when being screwed on.

5. Fit the chuck on to the headstock of lathe, turn the nose-piece, face it, and screw it with outside comb chaser—Ch. XVI, Fig. 18 (13)—to the size that is convenient for the auxiliary chucks.

The two studs are cast on, so that they can be tapped lightly with a hammer to tighten the chuck on to the spindle, and also to loosen it. If the stud farthest from the headstock is not wanted it could be sawn off.

Auxiliary Chuck.—1. Turn pattern in wood.

2. Obtain casting.

3. Hold in a chuck, bore out, and screw to fit without any shake on to nose-piece of master chuck. A number of these should be fitted and then left so that they could be fitted to any work that comes along.

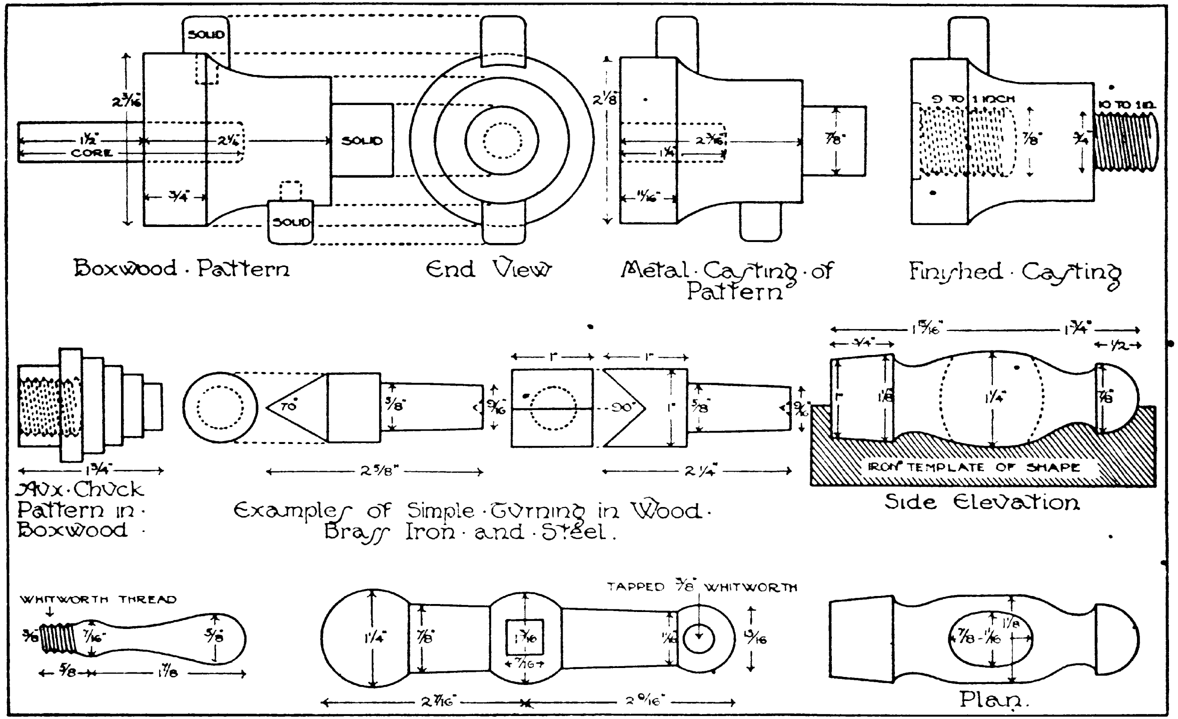


FIG. 6.—Top row—Pattern, casting, and finished casting of master chuck.
Second row—Aux. chuck-steel centre, vee block centre, hammer head.
Bottom row—Small handle and cross bar for a balanced handle, plan of hammer head.

A Loose Centre.—1. Cut off a piece of steel 1 in. longer than the finished length.

2. Anneal, square the ends, centre them

3. Drill $\frac{1}{8}$ in. or $\frac{5}{32}$ in. holes $\frac{3}{8}$ in. deep in both ends.

4. Countersink both ends, angle of countersink to be the same as that of the centres being used.

5. Fix a lathe dog on one end, and screw a carrier chuck on the nose-piece of lathe headstock and hold it between the centre, seeing that it runs freely without shake; oil centre and tighten up bolts and set screws on lathe so that the work cannot jump out while being turned.

6. Turn to correct size and shape, using the slide rest, and note that the cutting edge of tool is at the centre of the work

Vee Block or **Drilling Plug** —1 Cut off a piece of $1\frac{1}{8} \times 1\frac{1}{8}$ in. iron 1 in. longer than the length of the plug This could be turned from the square stock, or the taper end could be brought to a welding heat and swaged down.

2. Anneal it, square the ends, centre them

3. Drill $\frac{1}{8}$ in. or $\frac{5}{32}$ in. holes $\frac{3}{8}$ in. deep in both ends.

4. Countersink both ends, angle of countersink to be the same as that of the centres being used.

5. Fix a lathe dog on one end, and run between the lathe centres so that it turns freely but does not shake.

6. Turn accurately to shape, taking a light cut only over the corners of the square.

7. Cut out vee piece with a hack saw.

8 File up accurately, and see that the centre of the angle is in the centre of the plug.

9. Finish off with a piece of fine emery cloth wrapped once round a flat file, taking care not to rock the file.

Hammer Head.—1. Cut a templet out of thin metal to exact shape of hammer head. Proceed as instructed in Nos. 2, 3, 4, 5 of a loose centre.

6. Turn to exact size and shape, using hand tools for the curved portions. For method of holding hand tools when turning iron or steel, see Fig. 8, p. 83.

7. File the two flat surfaces as shown on plan.

8. Mark centres on both sides of hammer head for two $\frac{7}{16}$ in holes.

9. Chip a small level surface on sides of centre marks so that drill can start without running off.

10. Drill $\frac{1}{4}$ in. or $\frac{3}{16}$ in. holes right through by drilling from each side alternately.

11. Drill the $\frac{7}{16}$ in holes, plugging the first hole drilled with a piece of iron or brass before commencing to drill the second hole.

12. Clip and file out the oval hole to the correct size, tapering it slightly from each side.

13. Finish off hammer head with smooth files and emery cloth.

14. Bring hammer head slowly to a red heat and quench out in oil or paraffin.

15. Fit the end of a piece of iron about 2 ft. long to the hole for the shaft which is called the eye and polish up the hammer head ready for tempering.

16. Heat the end of the piece of iron which has been fitted to the eye in the hammer head to a white heat and place quickly in the hole, keep reversing the hammer head, this draws the temper of the centre portion, and as the face or pane are tempered to the correct hardness quench out in oil.

17. Fit with a hickory or ash shaft and a wrought-iron wedge.

Balanced Handle or **Swape**.—1. Cut off a piece of $1\frac{3}{8}$ in. round iron 1 in. longer than the finished length, also a piece for the handle proper.

2. Anneal them, square the ends, centre them.

3. Drill the holes and countersink them as described in previous paragraphs.

4. Hold them as previously described and turn to the correct sizes.

5. Drill a $\frac{3}{8}$ in. hole in centre of cross bar, file it square with a square file.

6. Drive a $\frac{7}{16}$ in. parallel drift through.

7. Drill and tap the smaller end of cross bar, but the hole must not go right through.

8. Screw with the adjustable stocks and dies the small handle and fit into cross bar.

9. Finish off with fine emery cloth and oil.

Notes on Turning.—As all these objects involve various kinds of turning and in different materials, the methods of holding the turning tools shown in Figs. 7 and 8 will no doubt be useful, and the very different methods of holding the turning tool when turning iron or steel, and when turning brass or similar metals, should be noticed. When turning iron or steel, owing to its tenacity and the danger of the tool "running in," it is necessary that the tool should be held with the utmost solidity; hence a large handle, giving a good firm grip, which enables the user to govern the pressure on the work being turned, is necessary. The illustration (Fig 8) shows the turning down of a mandrel with a graver. A graver is a piece of square steel ground off diagonally at about an angle of 35° to 40°, hardened and tempered to a straw colour for turning iron and steel. It will be noticed that the tool rest is as close as possible to the work, in order to provide the fulcrum for the opposite corners of the graver.

When turning brass (see Fig. 7, p. 83) the rest should be placed so that the turning tool has free play, thus enabling the turner to feel the cut, and also sufficient space for working around the curves, shoulders, etc. Ch. XVII, Fig. 22, Nos. 14, 15, 16, 17, illustrate the shapes of tools for turning brass and similar metals. Another point when turning is that the rest should be arranged so that the cutting edge of the tool will be at the centre line of the work. This also applies when screw cutting by hand. When roughing down iron or steel and using the slide rest the tool No. 6 on p. 210 should be used. No. 8 is for shoulders or angles, and No. 10 for finishing off.

FIG. 7.—Turning brass with scraper.

Lubrication.—This is a most important factor in all cutting operations, and it varies considerably under different conditions. The following table will be found useful, as it gives the various metals and the lubricant to use while they are being worked. A mixture of water 100 parts, soft soap 2 parts, soda 7 parts, and oil 30 parts, forms a good lubricant for general purposes. The water carries away the heat, and prevents the work from warping, the soda and soap prevent rusting of the work and the machine, and the soap and oil lubricates the cutting edge. This should be boiled for three hours thoroughly before use. The oil referred to here is commonly known as machine oil.

FIG. 8.—Turning iron with a graver.

Material.	*Lubricant.*
Tool steel	The mixture as above, or oil.
Soft steel	" " "
Wrought iron	" " "
Cast iron	Dry, no lubricant at all.
Brass	" " "
Gunmetal	" " "
Bronze, etc.	" " "
Copper	The mixture or oil.
Aluminium	Paraffin or turpentine.
Lead	Candle wax.

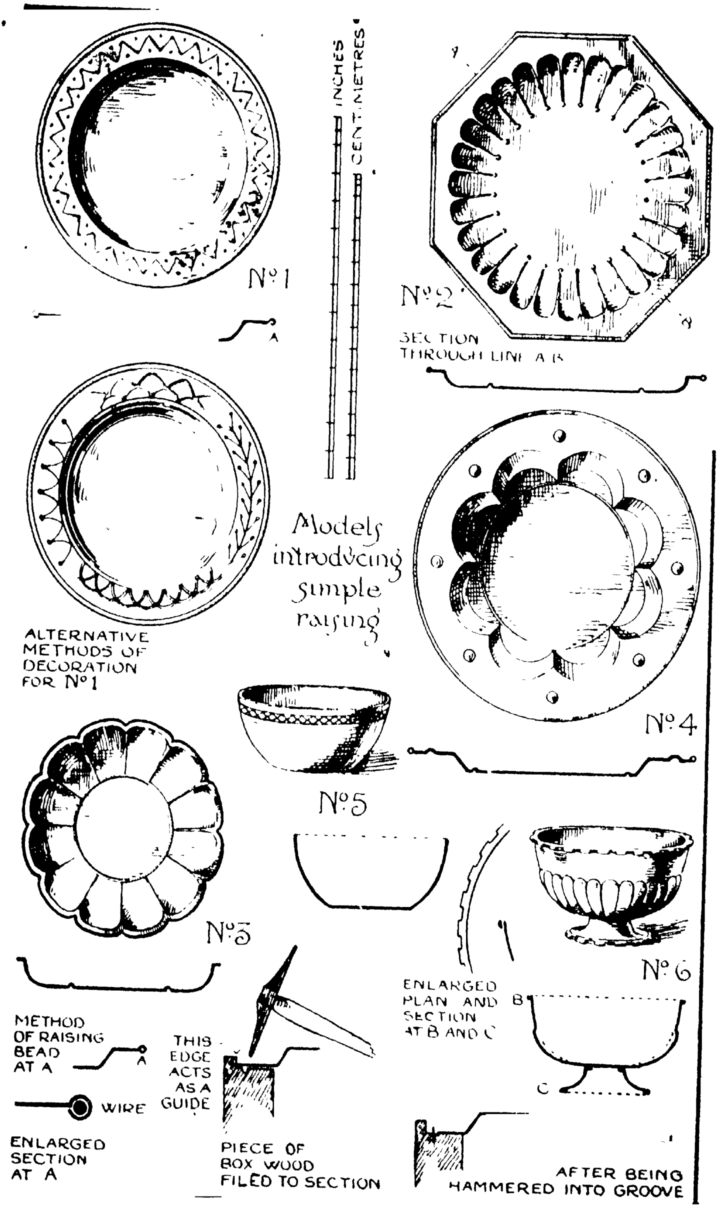

INCHES
CENT. METRES
No 1
A
No 2
SECTION THROUGH LINE A B
ALTERNATIVE METHODS OF DECORATION FOR No 1
Models introducing simple raising
No 4
No 5
No 3
METHOD OF RAISING BEAD AT A
A
WIRE
ENLARGED SECTION AT A
THIS EDGE ACTS AS A GUIDE
PIECE OF BOX WOOD FILED TO SECTION
ENLARGED PLAN AND SECTION AT B AND C
B
C
No 6
AFTER BEING HAMMERED INTO GROOVE

FIG. 1.—Examples of simple raised work.

CHAPTER VIII

THIRD YEAR MODELS (METAL)

HAMMERED DISHES OR PATERÆ AND BOWLS (Fig. 1).

THESE models can be used for a variety of purposes, the flat dishes for card trays, standing glasses on, etc., the simple bowls if tinned or silvered inside make nice sugar bowls, etc. They could be made of brass, gilding metal, copper, aluminium, German silver, or silver.

The Joints.—In the plain hammered plates and bowls there are not any joints, as they are worked up from the flat material, but those with a foot have the joints silver soldered, or fixed with very small rivets.

The Method of Procedure for making the dishes or plates (Fig. 1, Nos. 1, 2).

1. Make a full-sized drawing.

2. Cut a metal templet to exact shape of raising, depth, and width of rim.

3. Cut the metal out, allowing about ¼ in. over all extra for Fig. 1, Nos. 1, 2, 3, 4.

4. Cut out a piece of wood like that shown in Fig. 2 and fix to the bench.

5. Fig. 1, Nos. 1, 2, would be raised or hammered up with a double ball-ended hammer on the wood, as shown in Fig. 2. The nails shown act as guides so that if the edge is cut true, the hammered part must be raised true and circular, as you drive the metal down against the edge of the piece of wood a little at a time.

6. After taking one or two courses round the dish you flatten it with a mallet on a flat surface of wood or metal, and anneal it.

7. Repeat operation No. 5 until the plate is of the required depth.

8. Now planish it smooth and true on a round stake with a flat-faced planishing hammer, Ch. xvi, f. 21 (8).

FIG. 2. Raising a dish on a wood mould.

9. The rim is now made flat and the edge trued up, and the plate annealed again.

10. Make up a bed of pitch, consisting of a thick wood base about 2 or 3 in. larger all round than the plate, and mix some common plaster of Paris and tallow with the pitch. The plaster is to harden and toughen, the tallow is to make it flow and soften it. Lay on the board a bed of this about 2 in. thick. Wait until it sets, then prepare some more pitch, pour some on the pitch block, grease the plate, pour some pitch on it, then put it on the block and weight it down, so that the warm pitch is pressed out from underneath the plate, this prevents the formation of air bubbles underneath the metal.

11. Clean the plate on the pitch when cold, and mark out the design.

12. Now trace in the design with the tracers (Ch. XVI, f. 21, Nos. 10 and 11) and the hammer (Ch. XVI, f. 21, No. 9), holding them in the manner shown in Fig. 3. Plate No. 1, Fig. 1, would only be worked on back, but plates Nos. 2, 3, 4, Fig. 1, would have to be worked up on both sides.

13. After the embossing of plate No. 2, Fig. 1, the edge would be trued up and wired as shown at the bottom of the page, but Nos. 1 and 4, Fig. 1, would, when the centre part was finished, have the edges wired and the designs on the rims embossed last.

14. These would now be cleaned up and polished and lacquered if required.

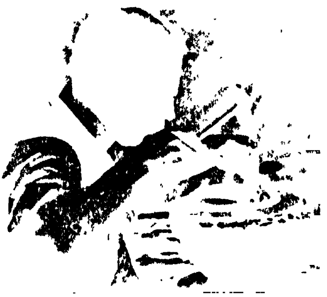


FIG. 3.—Method of holding a chasing tool.

Fig. 1, No. 3.—1. This would be raised up by beating it into a hollow, carved out of a solid piece of wood, usually a piece of a tree trunk, with a ball-headed hammer, then smoothed up and planished on a round stake.

2. Now place it, bottom upwards, on the pitch, clean it, draw the design, and line it in, as described for plates Nos. 1, 2, Fig. 1.

3. Take it off the pitch, clean it, and bed it in the pitch again, the hollow side upwards.

4. Work it up to shape and finish it off.

5. Flatten it, cut out the edge and smooth it up with a half-round smooth file.

6. Clean it up and polish, lacquer it if desired.

Fig. 1, No. 4.—This would be made in a different way to the others owing to the design.

1. Draw the design on the metal by cleaning the metal with emery cloth and placing a piece of blue transfer paper between the drawing and the metal, then go over the design with an ivory scriber.

2. Scratch the design on the metal with a steel scriber, working carefully over the existing lines.

3. Lay the metal on a sand bag and work the design up with the punches

(Ch. XVI, f. 21, Nos. 10, 11, 12, 13, 14), working on both sides of the metal until it is roughly beaten into shape, then anneal it, and repeat.

4. Now place on the pitch, hollow side up, as previously described, and work the bottom down with boxwood punches. The pitch must be slightly warmed for this latter operation.

5. Now take it off the pitch, anneal it, put it on the pitch again, the bottom side up.

6. Work on it with boxwood punches and finally with steel punches.

7. Take it off the pitch, reverse it, and put it on again, always greasing the side that goes on the pitch.

8. Finish off with steel punches making it as smooth as possible.

9. Take it off the pitch, clean it, flatten it, and square up the rim.

10. Wire the edge as shown, that is, trim the edge of the plate true, then file a piece of boxwood to the size required, as drawn, and hammer the metal into the groove with a pening or grooving hammer, then lay the wire in the groove, and hammer the edge down and over it while the bead rests in the grooving tool (Ch. XVI, f. 21, No. 28).

11. Flatten the rim.

12. Lay the plate on a cake of lead and punch the small bosses up with a round punch of the correct size (see Ch. XVI, f. 21, No. 16).

13. Clean up and polish. It could be lacquered if desired.

Fig. 1, Bowl No. 5.—This is a little more difficult than the plates, but still comparatively simple.

1. Set out a full-size elevation of the bowl and make a templet of one side and along the bottom to the centre, so that when the templet is laid on the elevation the edge of the templet is on the outside of the line from the top edge to the centre of the bottom. This must be an outside templet, similar to that on p. 80.

2. To obtain the size of the blank required to make this bowl, and as the bowl is part of a sphere, draw a straight line from the extreme outer edge to a point that would be the centre of the half ball if the curved sides were carried round. This would be the radius required. For example, as the bowl drawn is 6 in. in diameter and 2½ in. deep, and we made it into a half circle instead of a flat bottom, it would measure 6 in. in diameter and 3 in. deep, and a line drawn from the centre to the edge would measure 4¼ in., so that the diameter of the blank required would be 8½ in. This is the method often adopted for finding the diameters of the blanks required for bowls or segments of circles, but there are many other methods.

3. The blank should now be hollowed up as described for the plate No. 3, Fig. 1, taking care to keep any wrinkles out.

4. Anneal it and hollow it up a bit deeper.

5. Now put a round stake (Ch. XVI, f. 21, No. 26) in the vice, or in a square hole in the hollowing block, and holding the bowl on the stake as shown in Fig. 4,

take a course round it, driving the metal away from you and in a downward direction, using a boxwood mallet as illustrated. These courses must be done evenly, gradually working round and round towards the edge, and the same weight of blow being given. The blows must slightly overlap one another, and two should not be given in the same place.

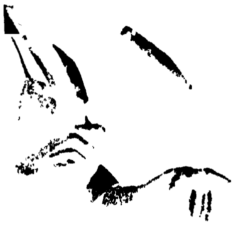


FIG. 4.—Raising a bowl on a stake.

6. The bottom of the bowl should now be flattened on a polished stake (Ch. xvi, f. 21, No. 22) and the edge trimmed off smooth, then annealed, pickled, and dipped up bright.

7. It should now be planished all over on a suitable stake, with the planishing hammer (Ch. xvi, f. 21, No. 8) seeing the hammer and stake are both well polished, and keep the hammer marks very even and do not let the edge of the hammer mark the bowl, as these marks are very difficult to remove.

8. Grease the interior of the bowl, and fill with pitch.

9. When the pitch is set, rest it on a sand bag and draw on the design for the banding, and line it in with a thin tracer (Ch. xvi, f. 21, No. 10). Then warm and remove pitch, and clean with paraffin and sawdust.

10. Polish it with rouge.

11. If required to be tinned, scour the inside with sand and water or emery cloth, paint over the parts that are not wanted to be tinned with whiting, heat the bowl, rub it over with sal ammoniac, pour in some melted tin, swish it round, pour it out again, heat the bowl, and wipe the surplus tin off with some tow dipped in silver sand and powdered sal ammoniac.

Bowl with Foot, No. 6, Fig. 1.—This is a little more difficult than No. 5, Fig. 1, and involves silver soldering and brazing.

1. Raise the bowl and the foot as described previously for No. 5, Fig. 1.

2. Fill the bowl with pitch, and when cold draw on the design to be raised.

3. Trace the design in as described for the bowl No. 5, Fig. 1.

4. Remove the pitch, and clean the bowl as described for the bowl No. 5, Fig. 1.

5. Rest the bowl on the sand bag and slightly raise the ornament from the inside with the embossing tools (Ch. xvi, f. 21, Nos. 13, 16).

6. Obtain some half-round material, the same that the bowl is made of. If not, make some from round wire by filing one side flat, or hammering one side flat while the wire is in a grooving tool (Ch. xvi, f. 21, No. 28).

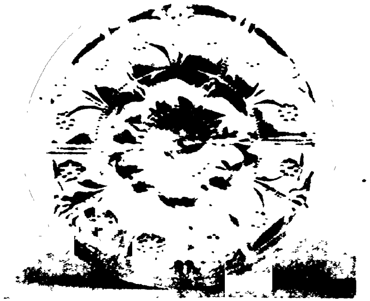
7. Bend it up into a circle and braze the ends together so that it fits on to the bowl tight.

8. Repeat this for the foot.

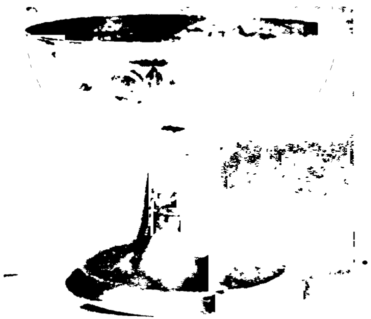
9. File the notches in the rings as illustrated.

10. Place the rings in their correct position and silver solder them on

(1) Silver jug, eighteenth century. V. and A. Museum.



(2) Silver dish chased and repoussé V. and A. Museum, English, 1650



(3) Silver "mazer" cup, second half fourteenth century. V. and A. Museum, lent by J. C. Robinson.

FIG. 5

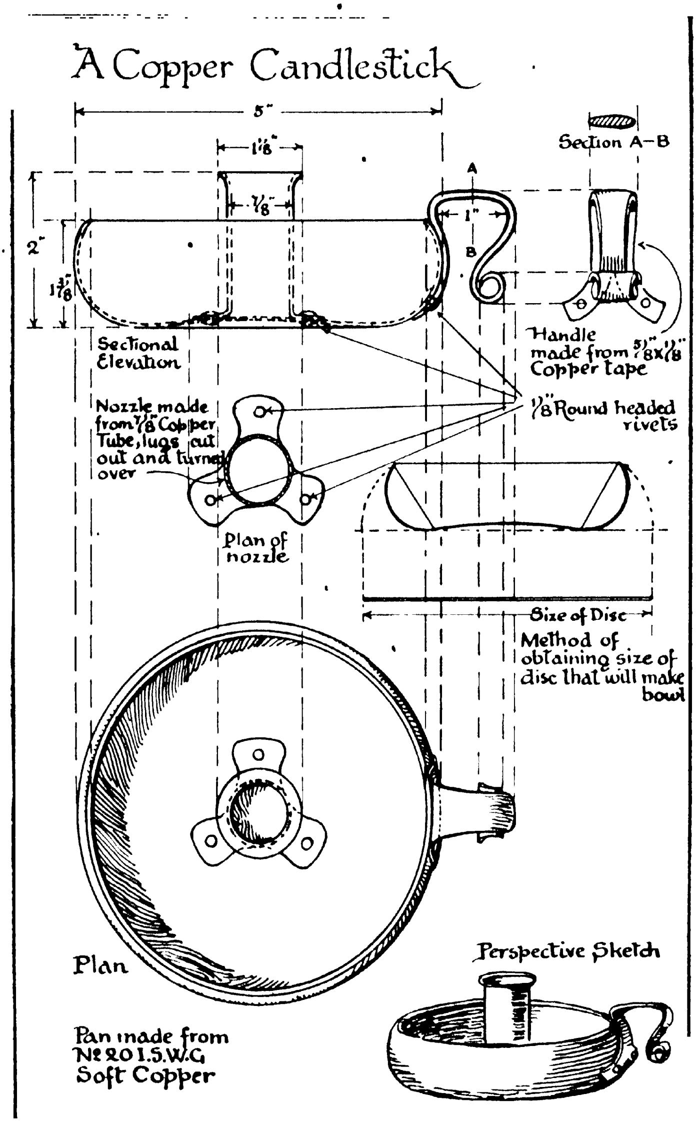

A Copper Candlestick
5"
1⅛"
⅞"
2"
1⅞"
A
1"
B
Section A–B
Sectional Elevation
Handle made from ⅝" x ⅛" Copper tape
⅛" Round headed rivets
Nozzle made from ⅞" Copper Tube, lugs cut out and turned over
Plan of nozzle
Size of Disc
Method of obtaining size of disc that will make bowl
Plan
Perspective Sketch
Pan made from No 20 I.S.W.G. Soft Copper

FIG. 5A.—A copper candlestick.

11. Pickle, dip, and clean the bowl up all over.

12. Polish with rouge, and tin or silver the inside as required.

The Decoration.—This is all on simple lines, and involves only simple processes. The decoration on plate No. 1, Fig. 1, could be omitted, thus simplifying it, and the number of flutes in plate No. 2, Fig. 1, could be reduced, and the ornamental band on plate No. 5, Fig. 1, could be left out without affecting them to any great extent

Special Features.—They are the introduction of simple raising, the combination of raising and embossing, and methods of stiffening the edges of pateræ, bowls, etc.

The illustrations in Fig. 5 are from objects in the Victoria and Albert Museum. They are shown as examples of more advanced work but of the same kind as the plates and bowls shown in Fig. 1.

The Jug (1), which is of silver, is of very simple construction and involves only simple processes. One could be designed on similar lines, and made as follows: The body made in two halves and silver soldered together, the junction being hidden by a piece of beading, the neck piece being decorated while in the flat, then bent up and joined together; the foot hammered up and decorated; the handle modelled on an iron core, and cast in plaster and then in metal. Repeat this process for the thumb piece and hinge, which appear as if in one piece. Hammer up the lid. Now join the neck piece on to the body, load with pitch and touch up or finish the ornamental details. Unload the pitch, clean up and fix the foot. Fit up the lid and handle together, then take apart, and fix the handle to the body Now finish off, clean up, and polish. Lastly fix the lid on, and give it a final polish.

The Silver Plate, Fig. 5 (2), needs no comment. It is of English workmanship of the date 1650, and is an example of punch decoration.

The Silver Cup, Fig 5 (3), is a prize cup of the second half of the fourteenth century, and was lent to the Museum by J. C. Robinson, Esq It is very graceful in form, and the style of decoration very simple and pleasing.

TRIPODS.

Subject and Uses.—The footman or tripod illustrated in Fig. 6 is a most useful article for standing on the hearth, as kettles, plates, etc, can thus be kept warm. The top lends itself to a great variety of geometrical designs, and could be cast or pierced.

The Joints.—These are riveted joints of three kinds, namely, tenoned and riveted, flush or secret riveting, simple riveting.

The Processes.—Make a drawing full size of the stand, from this make separate drawings on strong paper of the side view of leg as shown in Fig. 6, also plan of the top ring A, plan of the supporting ring B, and a tracing of the top. If a number of the same pattern are being made, a quarter templet of thin sheet metal would be advisable. The next step would be to make the legs, only the

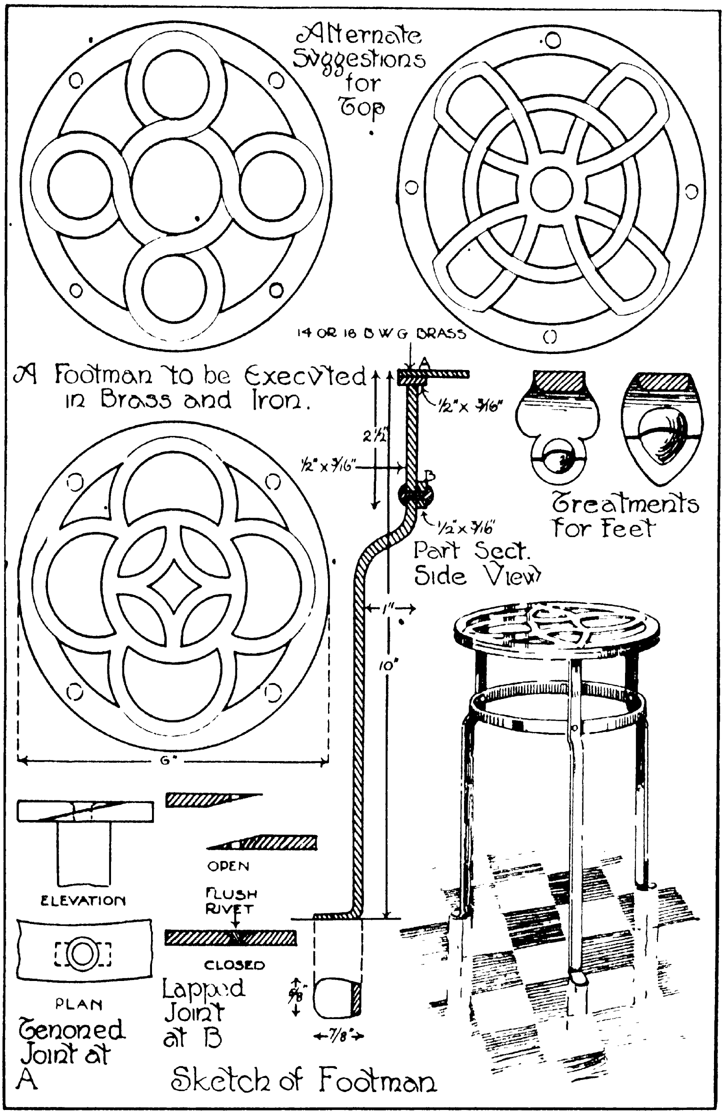


FIG. 6.—A footman or tripod with alternate suggestions for the top.

foot would require to be forged, the bending could be done cold, and the tenon at A cut down between two cutters in the lathe, or cut down with a hack saw and filed. The top ring should now be bent into shape while hot over the beak of the anvil or on a sugar-loaf mandril, then fitted and riveted together as illustrated, then the legs fitted to the top ring but not fixed. The ring B should be bent up cold round a former, fitted and riveted together as shown. The next step would be to drill the holes in the legs and in the ring B. Now rivet the legs to the ring at A, then rivet them to the ring B. The tracing of the top should now be transferred by means of carbon transfer paper to the sheet brass, or the tracing might be gummed on direct. Small holes should be drilled now where necessary for the insertion of the saw blade, and then, holding the fret saw as illustrated in Fig. 7, cut out the design. The ornament should be trimmed up with small files, mark and drill the holes for riveting to ring A and anneal the rivets. The ironwork of the stand should now be cleaned up or painted, and the top plate polished; the top plate can now be riveted to the stand and given a final polish. It should not be lacquered.

FIG. 7. Saw piercing in metal.

Decoration. This is mainly in the top plate, but a great variation could be made by putting a pierced band where ring B is, or the legs could be shaped, twisted, or even turned, but it all adds to the amount of work. The brass top plate could be without piercing if preferred, and a design could be engraved very strongly or even other metals might be inlaid.

Special Feature.—This is the top, as it gives such a fine opportunity for the introduction of an original geometrical design.

AN OIL-CAN

Subject.—An oil-can, a most necessary and useful object in a metal workshop, and in making this a large variety of processes have to be gone through.

The Joints.—They are lap, folded, cramped, riveted, soft soldered, and screwed.

The Processes.—The full-size elevation should be set out, and from this the development of the body and the handle. The drawings of the two patterns, allowing for shrinkage and turning, should be made full size. Then the two patterns could be turned out of boxwood, working accurately to the drawings. These patterns should be sent to the foundry to be cast in brass or gunmetal, while the other parts are being proceeded with. The next step is to cut out the development of the body and use it as a templet, or develop the body on to the metal being used, which should be 26 or 24 I.S.W.G., and cut it out with the snips; the burr should be rubbed off with a file, and the body bent up to shape on the funnel stake (Ch. XVI, F. 21, No. 24). If the joint in this is going to be the

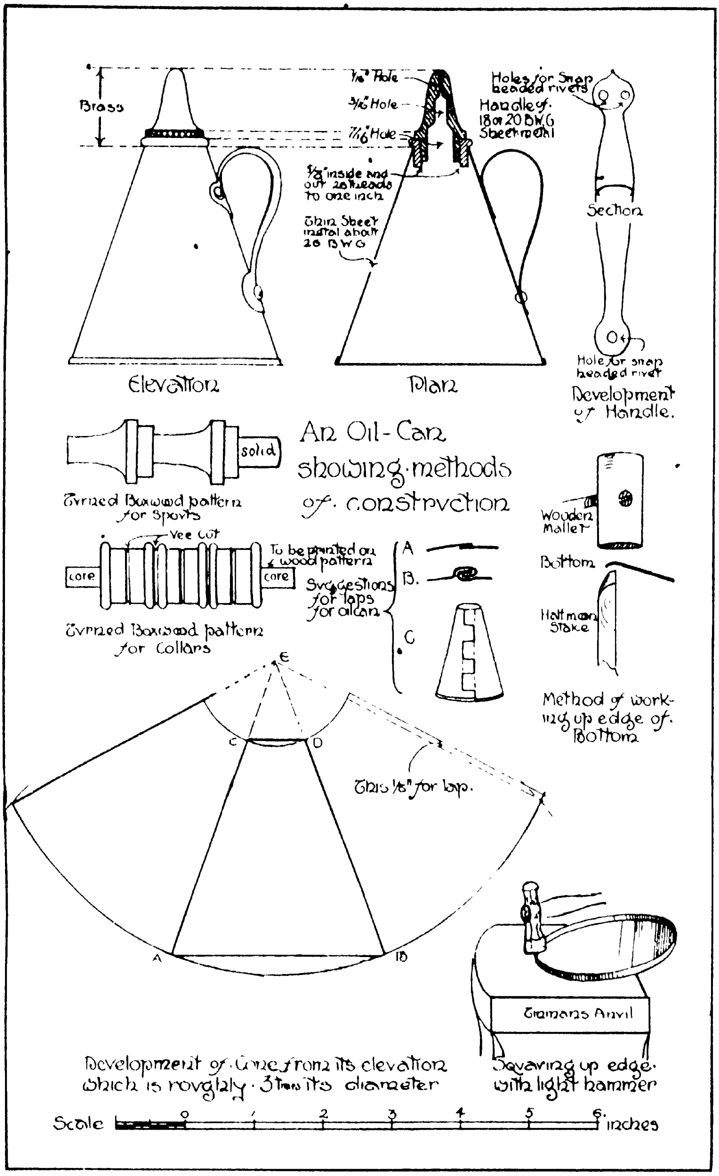

Brass
1/16" Hole
5/16" Hole
7/16" Hole
3/8" inside and out 26 threads to one inch
Thin Sheet metal about 26 BWG
Holes for Snap headed rivets
Handle of 18 or 20 BWG Sheet metal
Section
Hole for snap headed rivet
Elevation
Plan
Development of Handle.
An Oil-Can showing·methods of· construction
solid
Turned Boxwood pattern for Spouts
Vee cut
core
core
To be painted on wood pattern
Turned Boxwood pattern for Collars
Suggestions for laps for oilcan
A
B.
C
Wooden Mallet
Bottom
Halfmoon Stake
Method of working up edge of Bottom
E
C
D
This 1/8" for lap.
A
B
Tinmans Anvil
Development of Cone from its elevation which is roughly 3 times its diameter
Squaring up edge with light hammer
Scale 0 1 2 3 4 5 6 inches

FIG. 8.—An oil-can, showing methods of construction.

folded joint B or the clamped joint C, the edges should be prepared before bending the body into shape. When the body has been bent to shape the seam should be set down, so obtaining a neat and close joint, and the body measured and compared with the drawing. The circle for the bottom could now be cut out with the straight snips and trimmed up, a line drawn on it to correspond with the outside diameter of body, and the edge turned up as illustrated. The handle should now be cut out, the holes punched, and worked up to the shape required, and the spout and collar turned and screwed. The screwing could either be done with the taps and dies, or on the lathe with the inside and outside chasers as shown on p. 206. For method of holding turning tool for brass or gunmetal see Fig. 7, Ch. VII. The handle should now be fitted to the body and riveted on, and the collar soft soldered in position from the inside, also the inside ends of the rivets to prevent leakage. The bottom should now be fitted to the body and poppled, that is, it should be placed on a polished stake and struck a few blows with a light planishing hammer, thus making it springy. This allows the oil to be squirted out by pressing the bottom in. The edge, or lag as it is sometimes called, should be worked down on to the sides of the body and soft soldered, only a very small amount of solder to be used. It could now be washed clean, and polished with dry rouge.

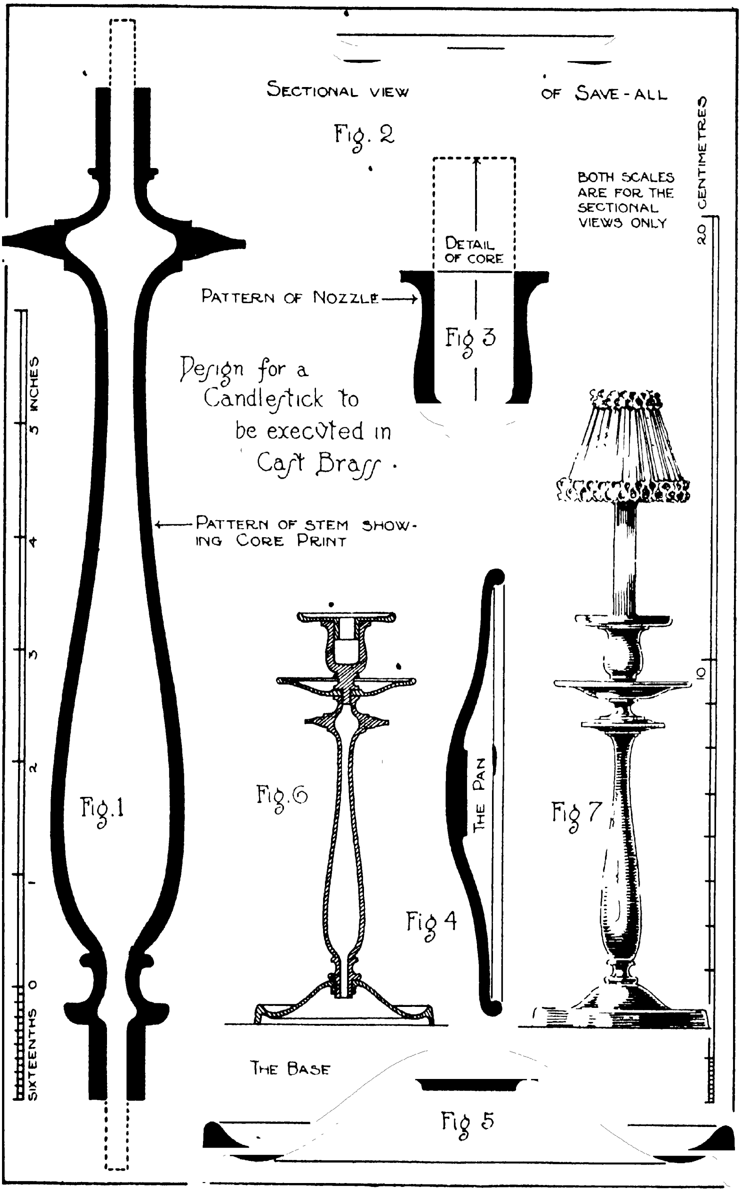

Sectional view of Save-all
Fig. 2
Both scales are for the sectional views only
20 centimetres
Detail of core
Pattern of Nozzle
Fig 3
Deſign for a Candleſtick to be execvted in Caſt Braſſ ·
Pattern of stem showing Core Print
Fig. 6
Fig. 1
The Pan
Fig 4
Fig 7
10
The Base
Fig 5
Sixteenths 0 1 2 3 4 5 inches

FIG. 1.—A candlestick in turned brass. Shaded section shows method of construction, thick black lines being sections of castings.

CHAPTER IX

SPECIAL MODELS IN METAL

FOR EVENING PUPILS AND OTHERS

TURNED BRASS CANDLESTICK (Fig. 1).

Object.—Useful model suitable for a second or third-year student; shows application of pattern and core box making, turning in wood and metal, screwing and drilling.

Material Required:—

Boxwood for patterns.
Sheet iron or zinc for templets.
Fine plaster of Paris for core box.
Iron rod for strengthening core box

Method of Procedure.—1. Make templet of pillar, Fig. 1 (1), for example see Fig 6, Ch. VII

2. Make templet for base, Fig 1 (5), and nozzle, Fig 1 (3)

3 Turn pattern of pillar, Fig. 1 (1), including projections shown by dotted lines.

4 Turn core print to inside line, Fig. 1 (1), including projections shown by dotted lines.

5. See that pattern and core print are both the same length and that the projections shown by dotted lines are the same size on pattern and core print.

6. Lay pattern on some moulding sand, and pack sand all round it and level with the centre, and see that surface of sand is flat so that when the pattern is removed a sharp outline is seen.

7. Remove pattern and lay core print in, and see if there is sufficient space all round for the metal to run. If not, correct it and test again.

8. Turn the nozzle, Fig 1 (3), to the outside line, including the dotted line.

9. Turn the base, Fig. 1 (5), inside first, then the outside and cut off.

10. Turn pan, Fig. 1 (4), and save-all, Fig. 1 (2).

11. Make core box in plaster with iron stays as shown on p. 96; where the method of making this is also described.

12. Get castings of these parts in brass or bronze as required.

13. Trim the rough lumps off the castings and immerse in weak pickle for about two hours.

14. Turn them to the correct shape, and screw the various parts so that they fit together. For method of holding turning tools see Fig. 7, Ch. VII. For turning tools suitable for this work see Figs. 22 (14-17), Ch. XVI.

15. Polish and colour down to whatever shade of colour is desired.

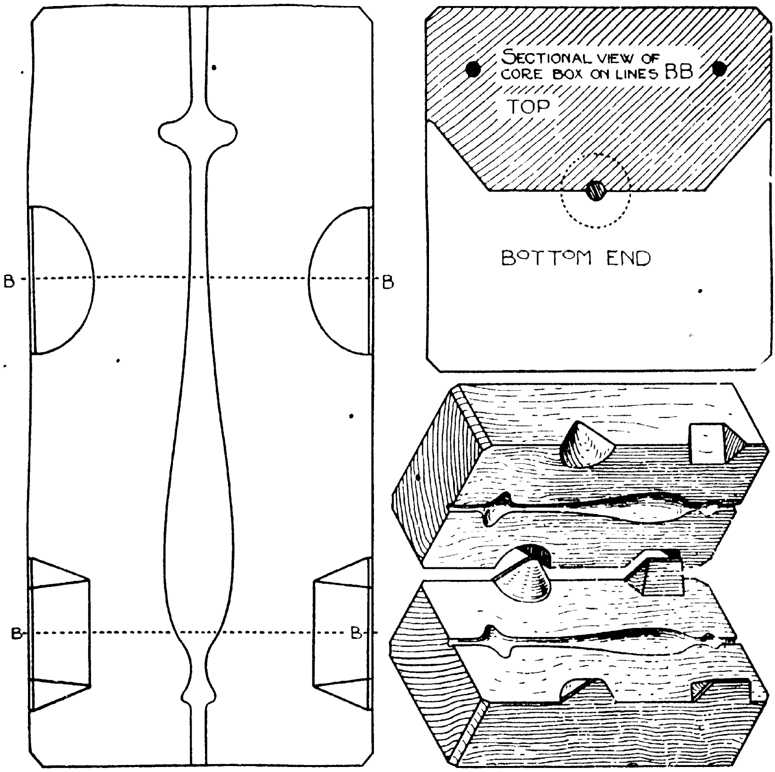


FIG. 2.—A core box.

16. Coat with lacquer and put together.

Decoration.—This article is decorative in itself, but it could be bronzed or gilt if required. If this candlestick was made of brass, then well polished and lacquered, this is all that would be necessary.

Method of Making Plaster Core Box.—

1. Have a box of moulding sand and level off the top.
2. Bury core print in to a depth of one-third or a little more, but not half.

3. Cut some pieces of flat thin metal the length, breadth, and about 3 in. deeper than you require.

4. Stick these in the sand, forming a box round the core print.

5. Take core print out of sand, well grease, and replace.

6. Mix up plaster of Paris with water to the consistency of cream and pour over core print to a depth of about 1 in. or a little more; let it set a bit, then put in iron wire stays and fill up with plaster.

7. When set, take off the sand and cut face down so that core print is embedded in the plaster exactly half-way; cut hollows for guides.

8. Do not take core print out of plaster but well grease core print, and face of plaster.

9. Place this half of core box on the sand, face uppermost; put pieces of tin round the sides as before, mix and pour plaster on this as before.

10. When set take off sand and trim off rough edges and square up to shape.

11. Wait until the whole box is thoroughly hard, then give a gentle tap and it will come apart in two halves, then remove core print.

WROUGHT-IRON CANDLESTICK (Fig. 3).

Object.—To embody various processes in a simple model, suitable for a second-year student.

Shows the application of chopping out, filing, drilling, turning, embossing, bending, brazing, screwing, fitting, and riveting.

Materials Required.—

7 in. of 1½ in. round iron for pillar.
6 in. of 1¼ in. round iron for feet.
5½ × 4 in. of No. 12 I.S.W.G. iron for base.
14 in. of ¼ in. square steel for spear.
1½ in. of 1 × ¾ in. for base of spear.
6 × 6 in. of No. 22 I.S.W.G. iron for shield.
2½ in. of ⅜ in. × No. 14 I.S.W.G. iron for clip.
2½ in. of ⅜ in. × No. 14 I.S.W.G. steel for spring.
2 in. of ½ × ¼ in. iron for filling.
3 × 4½ in. of No. 22 I.S.W.G. for save-all.
1 in. of ⅛ in. wire (iron or steel) for taper pin.
2 No. 4 B.A. iron round-headed screws.
1 iron washer $\frac{7}{16}$ in. hole.

Method of Procedure.—

1. Make thin metal templet of pillar, as shown in Fig. of Hammer Head, f. 6, Ch. VII, p. 80; also half templet of base and shield.

2. Dress up ends of iron for pillar, centre, drill small hole and countersink to fit centres of lathe.

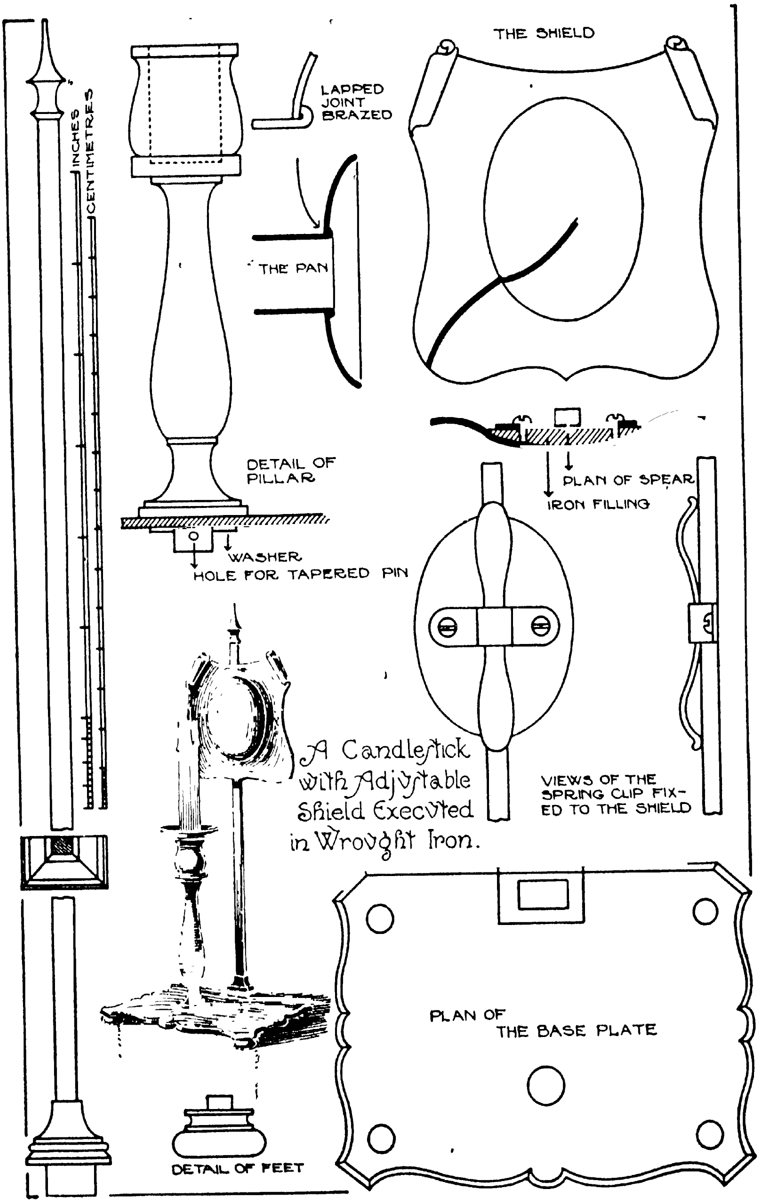


FIG. 3.—A candlestick with adjustable shield reflector.

3. Drill a hole as a guide in one end to the depth required for the socket, then drill a hole ⅞ in. diameter.

4. Put the iron in the lathe and turn to fit the templet. For method of turning iron by hand, see Ch. VII, f. 8. For turning tools, see Ch XVI, f 22.

5. Dress up ends of round iron for the feet. Centre, drill small hole, and countersink as before.

6. Turn feet to templet, cutting them nearly off but not quite, then finish cutting them off with hack saw.

7. Mark out base on No. 12 I.S.W.G., using templet. Cut out, file up, and chamfer.

8. Upset and spread end of ¼ in. square steel for spear head and file to shape.

9. File base of spear out of the piece of 1 × ¾ in. and fit spear to same, then braze together.

10. Cut shield out of No. 22 I.S.W.G. and trim up edges. Emboss centre and bend up the scrolls.

11. Take the 2 in. of ½ × ¼ in. and fit to hollow of shield, and braze in position.

12. Make spring and clip for pinching spear to shield and fit them.

13. Drill clip with holes to clear screws, drill tapping holes in filling of shield and tap with No. 4 B.A. Taper and plug tap, trying the screws when finished.

14. Make socket of save-all by rolling piece of No. 22 I.S.W.G. iron round a piece of tube or iron rod to fit the socket in pillar, and make simple lap joint and braze together.

15. Emboss pan of save-all. Cut out hole to fit socket just made and roll edge of socket over on to pan and braze from the underside.

16. Mark holes on base plate for feet, spear, and pillar, using templet, filing hole for spear rectangular with a square file.

17. Fit pillar to base plate and washer underneath, then mark hole for pin and drill.

18. Fit feet and rivet them on to base plate, leaving heads semicircular.

19. Put the whole thing together, and see if it looks square and upright.

20. Take apart, clean up thoroughly, dull polish, and lacquer with a colourless lacquer, and put together.

Decoration.—The decoration is obtained by forming the outlines of pleasing and simple curves, also by using the construction such as the raised rivet heads on the base to form a decorative feature. The chamfering is also a simple form of decoration as well as the shield, which is based on an Elizabethan example and is ornamented by the scrolled ears and raised centre which was characteristic of that period.

HINGES (Figs. 4 and 5).

Subject.—The hinges which are illustrated in Fig. 4 are Elizabethan in character, but the large one is distinctly Dutch.

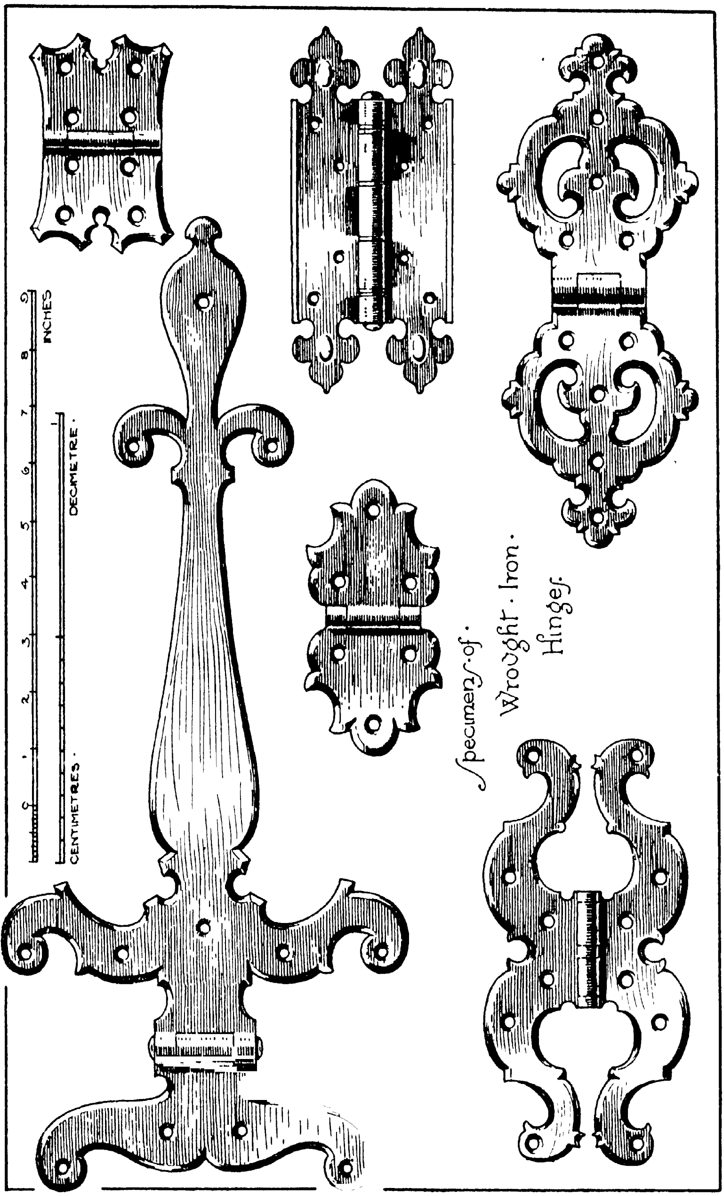


FIG. 4.—Examples of Jacobean hinges.

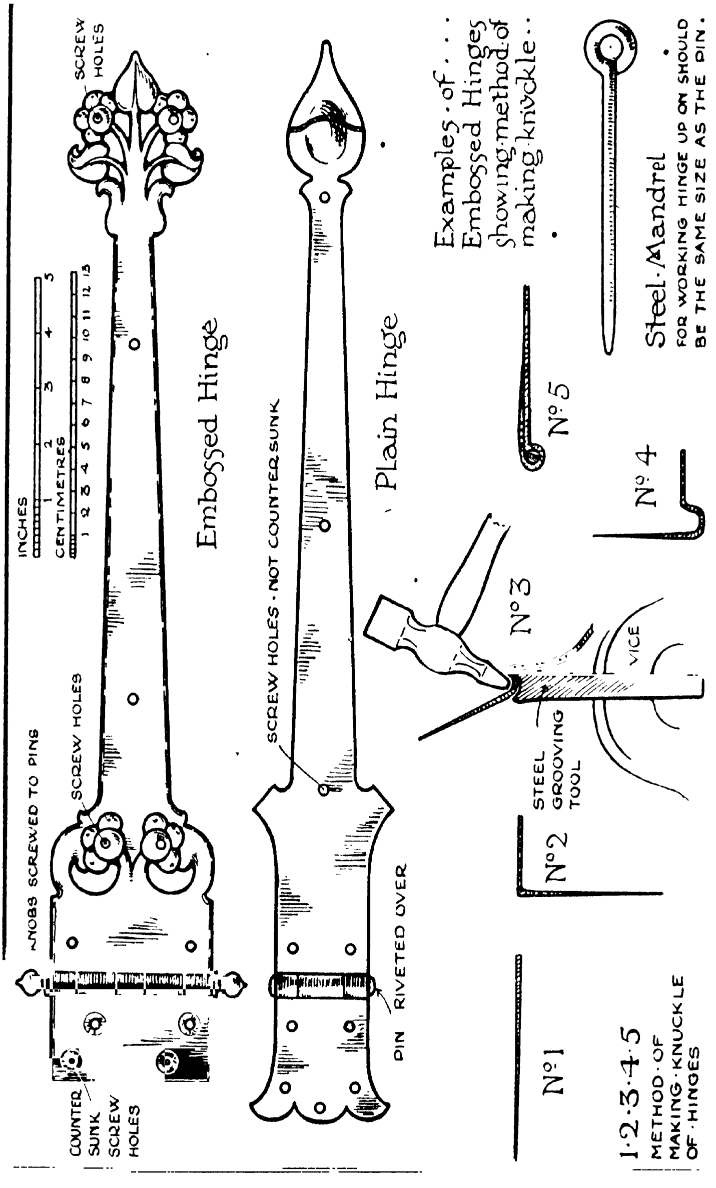


Fig. 5.—Strap hinges and a method for making the knuckle.

Those illustrated in Fig. 5 are modern, and any of these could be modified to suit existing conditions.

The Processes.—1. Make a full-size drawing of the hinge selected.

2. Make a tracing of the ornamental side, and transfer or gum on to thin sheet metal.

3. Cut the templet out, allowing it to butt up against the outside of knuckle.

4. Cut out the metal roughly to shape for the hinge and the flap, allowing for the knuckle.

5. Roll up the metal for the knuckles using the steel mandril, as illustrated in Fig. 5, Nos. 1, 2, 3, 4, 5.

6. Set out the knuckles for cutting, and notice should be taken that in a three-knuckle hinge the centre ones equal the other two, in a five-jointed one the two equal the three.

7. Cut the knuckles, file and fit them together neatly.

8. Lay the templet on the hinge and mark it out.

9. Raise or cut it out to the shape, and trim it up with files.

10. Drill the fixing holes, and file off the burrs.

11. Cut and fit the pin for the knuckle; if knobs are going to be used, the pin should be screwed, and the knobs drilled, tapped, and turned. For shapes of turning tools for brass set see Ch. XVI, f. 22, and for method of holding them see Ch. VII, f. 7.

12. The parts should now be polished, coloured, and lacquered.

13. Put it together, taking care not to scratch it; re-lacquer if necessary. See that the knobs do not bear on to the knuckle, they must screw down tight on to the pin.

The Decoration.—This is obtained by embossing, piercing, shaping of the outline and chamfering, while the iron hinges should be hammered all over the face and chamfers with a polished face hammer, which gives them a kind of texture, like those shown in Ch. XII, f. 9, but it must be done carefully and with judgment or a pitted appearance will be the result.

Note.—These models introduce knuckling and consequently careful fitting. As hinges are made in many different forms, to suit varied conditions, these could be modified, so giving an opportunity for adapting, or designing to suit the particular purpose for which they are required.

HANDLES (Fig. 3).

Subject and Uses.—In Fig. 6 are illustrated a number of handles of various types, involving many processes, and the use of many metals. With very little alteration they could be used for many other purposes besides fire implements. They are suggestions showing what is really practical, and they are placed in their order of difficulty. No. 1 is the easiest to make, while No. 12 is the most difficult. Before making any of these a working drawing must be made giving the various sections through the different parts. The drawings should be finished in ink.

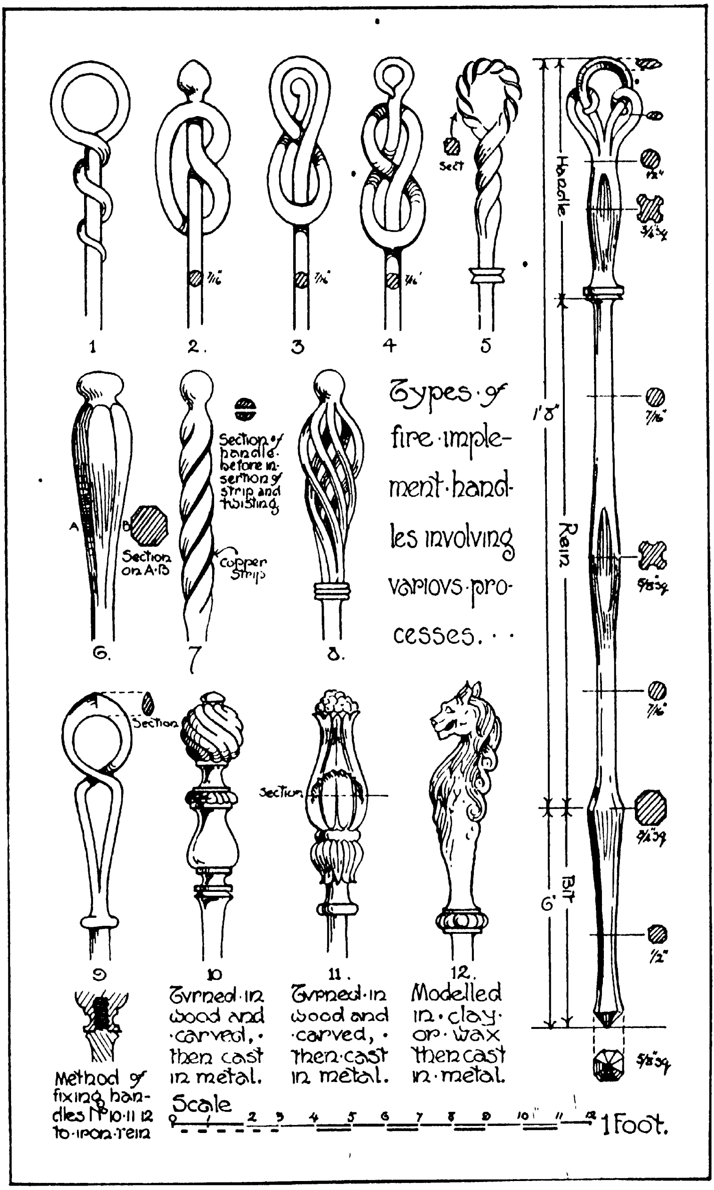

1
2.
3
4
5
7/16"
7/16"
7/16"
Sect
Handle
1'8"
Rein
Bit
6"
1/2"
3/4 sq
7/16"
5/8 sq
7/16"
9/16 sq
1/2"
5/8" sq
Types of fire implement handles involving various processes. . .
Section of handle before insertion of strip and twisting
Copper strip
A
B
Section on A·B
6.
7
8.
Section
Section
9
10
11.
12.
Turned in wood and carved, then cast in metal.
Turned in wood and carved, then cast in metal.
Modelled in clay or wax then cast in metal.
Method of fixing handles No 10·11·12 to iron rein
Scale
1 2 3 4 5 6 7 8 9 10 11 12
1 Foot.

Fig. 6.—Suggestions for handles in various metals.

The Processes.—No. 1. This is made of iron.

1. Draw down a piece of $\frac{7}{16}$ in. or $\frac{3}{8}$ in. round to the required length.

2. Bend it as illustrated in Fig. 7 (3), Ch. v, and twist it round the stem. This would have to be done while at a red heat.

3. Clean it up and finish it armour bright.

No. 2. This is made of iron.

1. Heat a piece of $\frac{7}{16}$ in. or $\frac{1}{2}$ in. round iron and tie a knot as you would with a piece of cord (experiment with the cord first), and only the hammer and anvil is necessary.

2. On the piece that projects shut a collar as illustrated in Fig. 7, No. 3.

3. After the collar has been shut on raise to a welding heat and shape it with a hammer.

4. Clean up with files and emery cloth, and finish it armour bright.

No. 3. This is also made of iron.

1. Practise with a piece of cord before commencing this.

2. Draw out a piece of $\frac{1}{2}$ in. or $\frac{7}{16}$ in. round until you have the required length, then roll up the end tightly and weld together to form the flat solid scroll end.

3. Bend up to shape.

4. Clean up and finish armour bright.

No. 4. This is also made of iron.

1 Experiment with piece of cord first.

2. Draw out a piece of $\frac{1}{2}$ in. or $\frac{7}{16}$ in. round to the required length.

3. Bend to shape.

4. Clean up and finish off.

No. 5. This is also made of iron.

1. Measure the exact size of loop and mark it off, then allow sufficient for drawing down and welding together.

2. Flatten the four corners slightly of the length marked off for the loop, and just past the marks.

3. Put a deep chisel cut down the centre of the flat on each corner.

4. Draw down each end from the square to the round.

5. Now heat and twist this centre portion.

6. Bend round a piece of round iron and bring ends together.

7. Weld ends together, scarf, and weld on to a piece of $\frac{1}{2}$ in. $\frac{7}{16}$ in. rod.

8. Heat between loop and end, cool and hold end in the vice, place a piece of round iron in the loop and twist.

9. Weld a collar on as illustrated in Fig. 7, No. 3. Before actually welding on the collar it would be better to thicken the stem by upsetting it, just where the collar is going to be. This prevents the stem wasting just where the collar is.

10. Shape the collar with a top and bottom tool or with a file.

11. Clean up and finish armour bright.

No. 6. This could be made of iron, or a wood pattern could be turned and filed up, then a casting could be made in brass or bronze, and this could be brazed to a rein of similar metal, and then filed up. If it was made of iron and used as an exercise in forging it would be made as follows:—

1. Have a convenient length of $\frac{7}{8}$ in. round and upset it where the thickest part is.

2. Draw the lower part away with top and bottom fullers until nearly to size.

3. Put neck in with top and bottom collar tools or with thin top and bottom fullers and shape up the knob with the hammer only.

4. Cut off excess material at bottom and scarf and weld on to the proper size rein.

5. Finish shaping up the flats on the handle and work the flats into the round gradually.

6. True the flat surfaces up with a file.

7. Finish off and polish.

No. 7. This is made of iron with a strip of copper inlaid. Yellow metal that will stand forging could also be used.

1. Get two pieces of $\frac{3}{8}$ in. square iron and make them half-round with a $\frac{1}{2}$ in. top swage.

2. Place them with the flat sides together and weld them at the top and bottom.

3. Weld a collar on at the top end to form the knob as illustrated in Fig. 7, No. 3.

4. Scarf the bottom end and weld on the rein.

5. Get the piece of metal you wish to inlay; thin the ends down and leave it a little wider than the half-round pieces.

6. Heat the handle and separate the two pieces of half-round with a thin chisel; insert the metal strip and close it all up tight.

7. Now heat it carefully all over; place one end in the vice, and holding the other end with the tongs or pliers twist it.

8. If the handle has got a little out of shape straighten it while hot with a wooden mallet.

9. Finish off and polish.

No. 8. The method of making this is shown in Fig. 7, and explained on p. 108.

No. 9. This should be made of iron and is a more difficult piece of forging. The shaping is done with the hammer. When finished it could be used as a pattern for casting from, by cutting one side just where they cross over, and bending it clear of the other side, so leaving it. If they are cast from this in copper, bronze, or brass, after they have been annealed and filed up it can be bent back again to its original shape and brazed together. If neatly done the joint hardly shows. If made of iron the method of procedure is as follows:—

1. Take a piece of $\frac{1}{2} \times \frac{1}{4}$ in., roughly mark off the length required and draw down the ends and round them, working away from the centre.

2. Shape and bend the ring at top simultaneously.

3. Finish bending and working it to shape, trim off the ends to the right length, close them together and scarf them.

4. Take the piece of iron for the rein, upset the end and shut a collar on as illustrated in Fig. 7, No. 3, leaving a piece projecting through.

5. Shape up the collar and scarf the piece projecting at end.

6. Weld the handle on to the piece projecting beyond the collar.

7. Clean up and polish.

No. 10. This would be most suitable if made in bronze, but it could also be made in any similar metal, and it is a pattern suitable for casting.

1. Turn exactly to the outline in some hard wood, such as boxwood.
2. Carve the ornament.
3. Cast in bronze.
4. Pickle it to remove the sand.
5. Turn all the plain parts in the lathe.
6. Chisel, riffle, and chase up the carved portions.
7. Polish with sand and crocus in the lathe.
8. Stain a dark brown as explained on p. 154.
9. Lacquer with transparent lacquer as described on p. 177.

No. 11. This one could be made exactly as described for No. 10, but as an alternative it could be modelled on a core, say an iron rod, in some plastic material, then cast in three parts in plaster; this would be the mould; this should be well greased, or soft soaped, then the pattern could be cast in this, but it should be strengthened with an iron core. The finish would be the same as No. 10 or varied according to taste.

No. 12. This would also look well in bronze, but it would have to be modelled as described above, and finished as No. 10. An excellent exercise in modelling in the round.

THE COMPLETE POKER.

This would be most suitable if all in iron, and it would be made in three pieces, namely, the handle, the rein, and the bit; these when finished would all be welded together.

The Handle.—1. Make the loop from $\frac{5}{8} \times \frac{1}{4}$ in.; shape and bend it, and scarf the two ends together.

2. Shape the grip part of the handle from a piece of $\frac{5}{8}$ in. square, thicken it up where the collar is and work up the collar, and draw away for the rein.

3. Scarf the end of the grip, and weld on the loop piece.

4. Draw down the two tail pieces from $\frac{3}{8}$ in. round iron, cut them off, and scarf the bottom ends where they are thickest.

5. Weld the two tail pieces on to the handle.

6. Dress up the handle, and put the grooves in with top and bottom fullers.

7. Curl the tails round the loop of the handle and see they set nicely.

8. Cut handle off where it has been drawn away for the rein, and scarf it just below the collar.

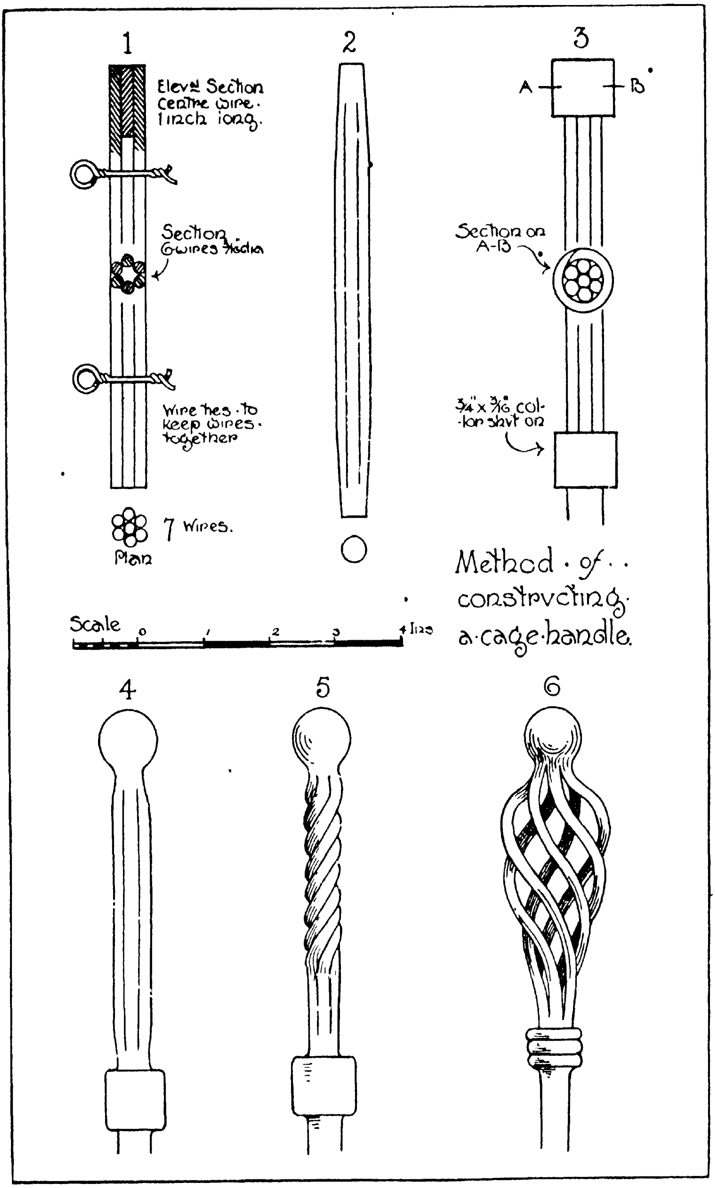


FIG. 7.—Processes in making a cage handle.

The Rein.—1. Get a piece of $\frac{5}{8}$ in. square, draw away each end, round up with top and bottom swages.

2. Shape up the centre boss and groove with top and bottom fullers.

3. Scarf each end. The ends of the centre rein should have been left a little thicker ready for scarfing.

The Bit.—1. Get a piece of $\frac{5}{8}$ in. square, work the bit roughly to shape, draw down the end and scarf ready for welding on to the rein.

2. Weld the rein on to the bit.

3. Cut the surplus material off.

4. Hold it by the rein and work the bit into shape and finish off.

5. Weld the handle on to the other end of the rein seeing that the overall length is correct.

6. Examine it all over, clean it up and finish off armour bright.

METHOD OF MAKING A CAGE HANDLE.

Subject and Uses.—The drawings in Fig. 7 illustrate the method of making a cage handle, which is very suitable for fire implements. This is excellent practice in light smithing.

The Joints.—These are all welded joints.

The Process.—1. Cut off six pieces of rod the length required, also two short pieces, and tie together with iron binding wire as shown in No 1.

2. Weld the ends together at the top and bottom as No. 2, holding them in the hollow bit tongs.

3. Upset and scarf a piece of $\frac{7}{16}$ in. round, scarf one end of the handle and weld together. This gives you something to hold it by.

4. Shut a collar on top and bottom as drawn in No. 3.

5. Heat the end to a welding heat and form the knob as in No. 4, then slightly round up bottom collar.

6. Heat evenly in the required place (see No. 5) and carefully twist it. The heating is important, or it will not twist evenly.

7. Carefully heat and unwind slowly, slightly tapping the knob, thus shortening the handle a little.

8. Regulate the cage so formed with flat and round-nosed pliers.

9. Shape bottom collar with half-round files.

10. Clean up with files and emery cloth, seeing that the wires are kept circular.

The Decoration.—The handle itself is decorative, but it could be enriched by shaping the knob or engraving it. The handle need not be made from round wire, but it could be made from $\frac{3}{16}$ in. square that has been twisted in opposite directions, so that as there are six wires you could have one twisted to the right and the next to the left and so on. When finished three wires would have a very gradual or slow twist.

Special Features.—This is the welding; and the ball knob should be done with a hammer, not filed. It is a good test for the appreciation of line and form, as a templet or guide is not used.

CHAPTER X

HISTORIC CRAFTWORK AND ITS APPLICATION TO CLASSWORK*

HANDCRAFT or manual training should—as has been previously indicated—not be restricted to mere hand training or dexterity, but should aim in the widest sense at a general understanding and appreciation of handwork, in fine pieces of craftwork and buildings. Whilst many pupils of handcraft classes must inevitably enter trades, it does not necessarily follow that the instruction should be in any sense vocational. The authors favour traditional methods because of their proved value and of their educational possibilities, but in the early years of handcraft training, the training is necessarily educational and cultural. The writers think it will be granted that those pupils who are later to enter the various artistic and mechanical trades, and who take up a regular course of technical work would, after a good handcraft course, be sure to profit by the more advanced training, and would also be able to proceed directly to technical courses.

The United Kingdom teems with fine entrances and doorways belonging to bygone periods, churches, cathedrals, castles, public buildings, colleges, and town and country houses presenting many splendid features. Fig. 1 represents a fine example of a doorway at Southgate Street, Winchester. The Brothers Adam designed many fine doorways of this type which may be recognized by their refined treatment of classic detail. "Adam" doorways are always composed of classic elements such as fluted columns and pilasters, cornices with dentils and "guttac," and the design of "Adam" doorways clearly indicates the source and inspiration of their work. They frequently designed doorways such as the one illustrated with overhanging "porticoes," and their designs for doorways are also characterized by finely designed "traceries" in the "fanlights." Portico is an interesting architectural term derived from the Latin word "porta" (a gate), and this root can also be traced in other interesting terms such as porch, portière, and portcullis. Portico means, literally, a range of columns or colonnade in front of a building. The entrance is set back from the columns as in the case of the West Front of St. Paul's Cathedral, and the Royal Exchange, London. The front of the portico is characterized by two fluted columns, classic in character but not copies of any of the columns belonging to the classic orders. The column itself would provide ample material for one object lesson, if an instructor treated this from earliest times and dealt briefly with the general growth and development to the time of the famous Greek buildings. The German archæologists, Von Reber and Winkelstein, in their various works deal at great length with early columns. Von Reber gives an interesting account of the primitive square pier in the rock-hewn chambers along the Nile. These were carved from solid rock, and the necessary support for the roof or ceiling was provided by leaving a square pier at intervals. To facilitate moving about these chambers, he considers that the corners were chamfered away, thus forming an eight-sided or octagonal column. The second stage appears to have been similar to an irregular octagon in sectional plan, and the third indicated above was an improvement on the octagon, for all the sides were equal in size or regular. A desire to improve upon this type is believed to have led to the sixteen-sided column by the simple process of doubling. The last development would naturally lead to a column almost circular in sectional plan, for Von Reber thinks that the Egyptians rejected the sleek rotundity of a circular column, in favour of one displaying greater preponderance of vertical line, which suggests greater strength and rigidity. A desire for ornament appears to have suggested channelling each side, and this would also accentuate the vertical line effect. Some authorities consider that the last stage represents the "proto-Greek" form which was later to develop into the columns of the Ionic, Corinthian, Doric, Tuscan, and Composite orders. The parts of a column are variously named shaft, neck, capping, base, frieze moulding, flutes, fillets, scrolls. The terms "entasis" and "module" are also introduced. If the column with corresponding parts of the order are dealt with, then the following terms would also be dealt with, viz. cornice or entablature, cornice moulding, frieze, frieze moulding, modillion, guttæ, dentil, pedestal, base, surbase, plinth, and abacus. It would be difficult to find a building which did not have parts corresponding to those mentioned above, and as each term has a distinct and separate evolutionary interest, and many are derived from the same roots as more commonplace words, it will be seen that a unique opportunity is afforded for linking up learning or culture with real things. Above the columns of the portico is the cornice, adaptations of which are seen in commonplace thing in every home. Thus the "frieze" of the cornice applies also to the cornice of a wardrobe or bookcase, whilst the moulding of the portico cornice has its parallels in a plaster ceiling cornice, sideboard, cupboard, etc. It could be pointed out in another lesson that all mouldings are made up of various elements found in the classic orders of architecture, such as "cyma recta" or right ogee, "cyma reversa" or reversed ogee, "corona" or drip, "trochilus" or scotia, "cavetto" or hollow, "ovolo" and fillet, "astragal" or bead, "fillet" or square, "torus" and "façia". Some of these elements occur in the cornice illustrated, whilst the frieze part introduces such terms as "swag," "husk," and "patera". To further illustrate the application of architectural terms to domestic features, one has only to quote "skirting," the moulded board round a room, or "plinth," a moulded base to a piece of furniture, the "architrave" of a door, and the frieze or picture-rail of a room. Ordinary room doors have "stiles," "muntings,"

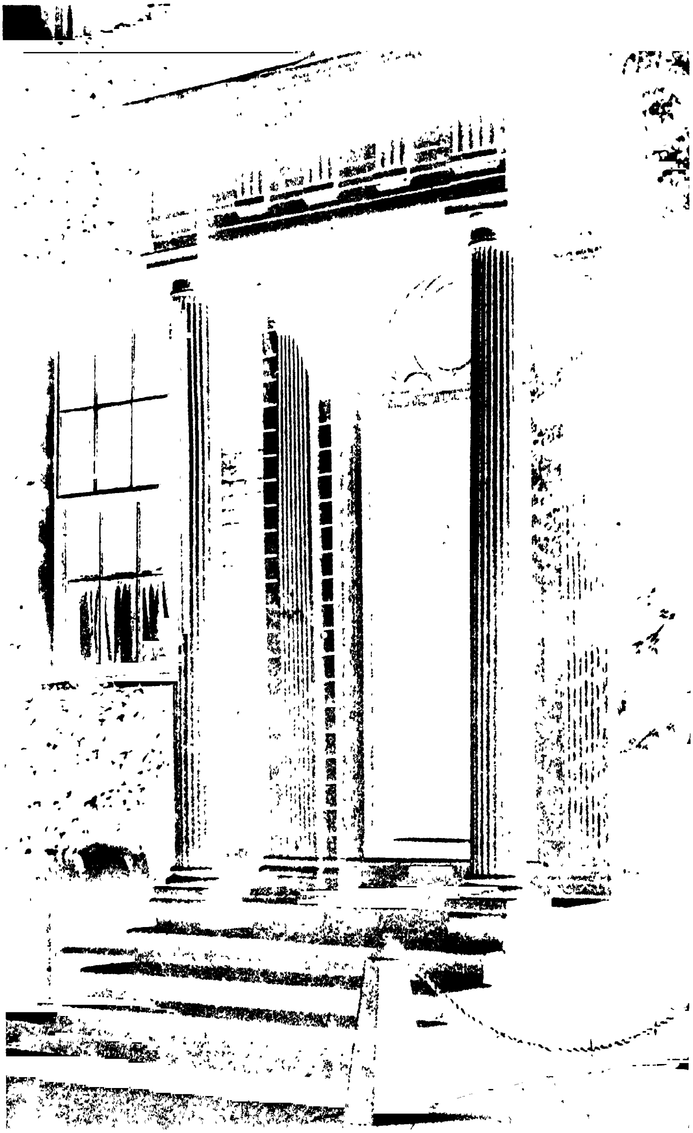


FIG. 1.—Doorway at Southgate Street, Winchester.

rails, and panels; Gothic windows have tracery, quatrefoils, trefoils, cinquefoils, lancet shapes, etc. An analysis of the terms is valuable, as indicating a common root origin with other common terms or words. It will be seen upon reference to the photograph that the back of the portico has two supporting "pilasters". The parts of these are named very similarly to the parts of the column, and the connexion between "pilaster" and the Latin word "pila," a column, pillar, and pilon, should be noted. The door itself in Fig. 1 gives another fine opportunity for the discussion and comparison of terms, and the fanlight above the door is a feature of the period. Whilst upon the subject of doorways, mention should be made of others than the one directly dealt with, such as those with semicircular arched tops, a feature of Roman construction, and usually made with tiles. Norman doorways in churches and monastic buildings are also semicircular, and massively built of stone with carved decoration. Gothic doorways usually have the pointed arch as a distinguishing feature, whilst those built during Tudor times have a characteristic Tudor arch, like a flat lancet shape. Below are given a few notes and suggestions in connexion with object lessons based upon the foregoing matter.

OBJECT LESSONS ON DOORWAY.

It is suggested that the class has visited a doorway, similar to the example shown, or has a large charcoal drawing of one displayed upon the wall.

Apparatus.

(*a*) Large charcoal sketch of doorway about 4 feet to 5 feet high.

(*b*) Blackboard, etc., for sketches, diagrams, and notes.

(*c*) Plaster cast of a typical piece of ornament (such as for example part of the frieze shown in photograph).

First Lesson.

1. The teacher to deal with the earliest known doorways, giving as an example a simple hole with stone or block rolled in position for security.

2. Evidences of ancient doorways and gates, as shown by Biblical and classical quotations.

3. Examples of ancient doorways, photographs or diagrams of ancient Egyptian remains, and museum specimens.

4. Identity of doorways. Teacher to deal with historical examples.

Second Lesson.

(*a*) **Roman.**—With semicircular head. Noting characteristics such as the principle of the Roman arch, which superseded the post and lintel construction used by the Greeks. Teacher to indicate by means of photos, diagrams, or slides, existing remains of Roman work showing these features.

(*b*) **Norman.**—With semicircular head, but built up with sections of stone. Note the decoration of these types and deal with examples in old churches, etc. Deal also with term "Norman" and historic matter.

Third Lesson.

(*c*) **Gothic**.—Pointed arch construction, class to note development from semicircular; with brief historical notes of the time. Illustrate by means of large diagrams the difference between Norman and Gothic moulded doorways.

(*d*) **Tudor.**—With flat-pointed arch construction. The open fireplace of Tudor times with arch corresponding to doorways.

Fourth Lesson.

A Georgian Doorway as per photograph (Fig. 1).

(*a*) Characteristics of the Georgian doorway.

1. Entrance door with fanlight above.
2. Portico with cornice supported by classical columns.
3. Without portico, but with pilasters and consoles supporting pediment.
4. Names and outstanding work of some eighteenth-century architects.
5. Customs of the Georgian period, and use of link extinguishers attached to doorways, etc.
6. Description of terms applied to the various parts of the Georgian doorway, column, pilaster, etc.
7. Indicate application of terms to domestic objects.

Fifth Lesson.

(*a*) Simple outline diagrams to be drawn of the Roman, Norman, or Gothic and Tudor arched doorways.

or

(*b*) Simple outline diagram of the Georgian doorway with names of parts indicated, such as

pediment cornice column
capping frieze pilaster

It will be seen from the above that quite a number of object lessons can be devised with the doorway as a basis. There is quite as much interest and scope when dealing with the fireplace and the window, whilst working backwards from a piece of furniture, with a discussion of the technical terms applied, will afford opportunities for introducing craft history as well as political history. From the ironwork side there is the gate, railings, and lighting structures, all of which have passed through definite developments and cannot properly be separated from the literary side of history.

OBJECT LESSON (METAL): EIGHTEENTH-CENTURY GATES.

The photograph reproduced in Fig. 2 of eighteenth-century ironwork is typical of the period, and like much more of our older work is fully understood only when we know something of the life of the time. Indeed such pieces of work can be used to illustrate and to help us to understand a phase of London life now past.

Life and property are now more secure, and the consequent feeling of comparative safety is reflected in the way our houses are built. The doors of our

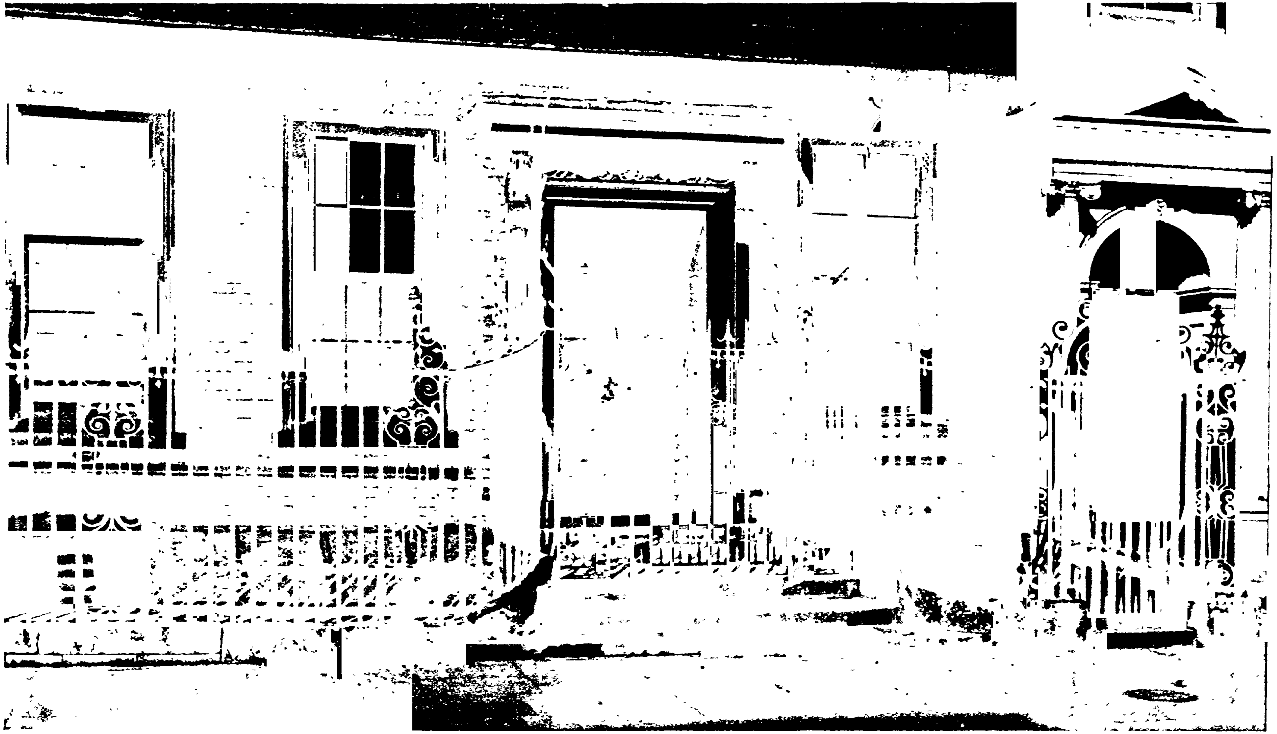


FIG. 2.—Ironwork at No. 44 Great Ormond Street, Bloomsbury (1708).

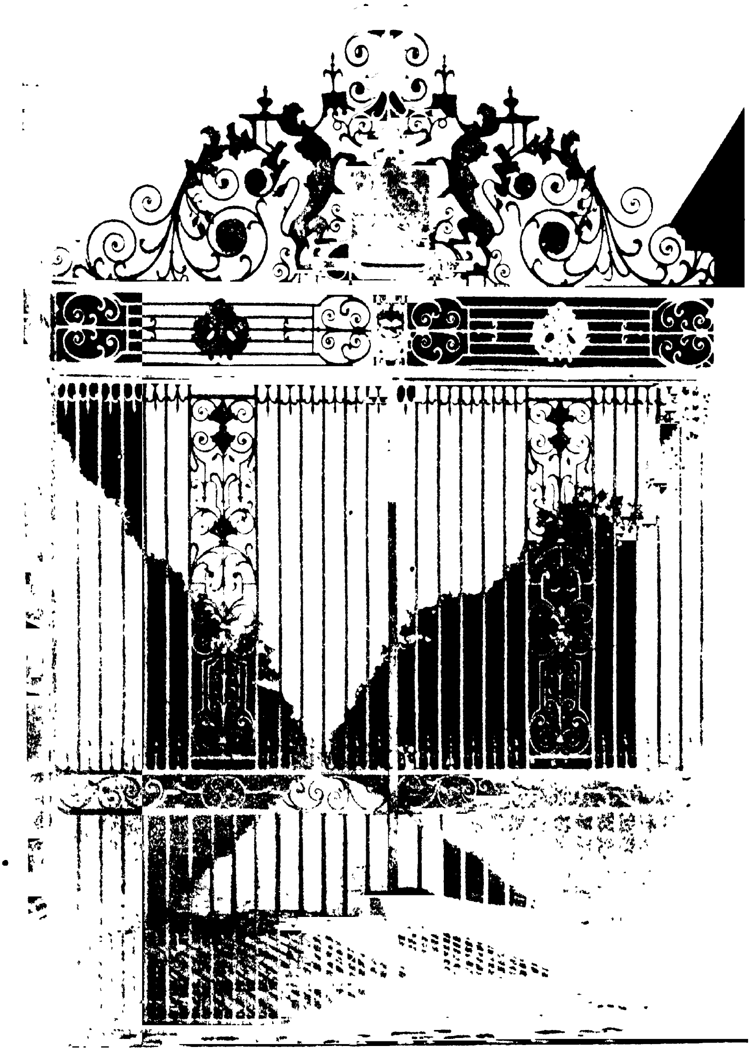


Fig. 3.—The Main Gates, Belton House, Grantham, Lincolnshire

modern houses and mansions do not require the iron bindings we find on the castle doors. Very frequently these bindings were elaborations of the hinges on which the door was hung. Elaborations of the hinges are to day put on church doors, but the only aim is adornment. When the moats with the drawbridges and portcullises disappeared large and very strong entrance gates of iron were made in the walls of the castles. These gates often had, in one of the leaves or panels, a small wicket-gate large enough to admit only one person at a time. Round the smaller but higher houses which became necessary because of the increased population, the walls were replaced by railings nearer the house, and these shut in the house and its forecourt as shown in the illustration. That the necessities and social conditions of the times account for the differences between the castle with its walls, moat, and drawbridge and the house shown is obvious, and whenever possible such connexions between historical facts and practical work should be pointed out.

Though around houses iron railings followed walls, it must not be supposed that their origin was merely replacing stone walls. Between the chancel and the body of Early Christian churches were iron lattice screens; inside the entrance gates of castles were strong lattice-work gates, and these with the rows of serried pikes in the hands of soldiers probably suggested iron railings. Defensive railings of plain lattice work were used by the Romans. Originally outside railings being for defence would be high, strong, and plain; inside ironwork, e.g. that in the *Rejas* or screens of the Spanish cathedrals made in the reign of Charles V., a noble and generous patron of the arts, was highly decorated. When railings were no longer merely defensive the inside decorations might have suggested decorations for outside ironwork. The actual work shown (Fig. 2) is good smiths' work, and is an advance on that of the earlier years where the smiths in their construction often copied woodworkers. Instead of punching holes in the horizontal bars which held the uprights, thus swelling the bar and in no way weakening it, they fastened the uprights with flat horizontal straps riveted through. It may be remarked that this punching was done when the iron was hot. Modern punching in the cold usually carries away the piece and leaves the bar weaker.

The large gate was lighted with oil lamps held by the rings shown on top of the lamp holders or lamp-irons, and these in turn were fixed to the lamp standards which are the tall panels on each side of the gate. The hook shown in front of the lamp-irons was for the ladder of the lamplighter. Such lamp-irons, though now common only on the houses of doctors showing their red lanterns, were then a feature of all houses of any size. A law was passed by the Mayor of London commanding all whose houses fronted any street, lane, or public passage, to hang out a lamp or lantern during the winter evenings from Hallowtide to Candlemasse (October to February). Sufficient cotton wick had to be provided for a light lasting from six to eleven o'clock. Public lamps were supplied where absence of these privately owned lamps rendered them necessary, and were provided for by fines of one shilling a head levied on those who failed to hang out a lantern. The work of the municipal authorities, the organization of the police, and education, have provided lamps, lessened dangers to citizens, and diminished brutal crimes; but on some old houses are still to be seen interesting examples of the old lamp standards.

Another interesting feature on some old houses reminiscent of dark unlighted thoroughfares are the link extinguishers, which can be seen one on each side of the lamp standards. These curious looking horns or trumpets, into which the link-boy thrust his torch to extinguish it, are made of sheet iron. Some of them had lids. Actual examples still remain on the fine lamp standards in Berkeley and Grosvenor Squares, the mansions in which date from 1700. The links or torches of tow and resin or of pitch-pine were kept in rings driven into the walls inside the entrance. In Florence cemented into the walls of the Strozzi Palace are some magnificent torch or link holders. These are of wrought and chiselled iron in the form of a winged dragon with a human face. The mouth holds a pin with a chiselled ring into which the torch fits, and on a bracket supporting the body is a carved and studded ring for the reins of the horses of visitors. There are many specimens of these torch brackets in the Albert and Victoria Museum. The man who loves his craft must now and again mourn the fact that gas and electricity, with their often ugly cast-iron standards, have made such fine examples of good work unnecessary.

The small spikes in the bottom bar of the centre gate are known as dogbars. Necessary as such bars might be to-day in some of our London suburbs, they were still more necessary in the city where, before the days of the dustmen and bins, the offal thrown into the streets provided rich repasts for hundreds of stray dogs. They are reminders of the less pleasant and less heroic things of old days.

Dropping now the historical aspect we shall remark on some features of the photograph that may be interesting to craftsmen. The pilasters which follow the ramps are of good proportion and are of the form usually known as the lyre form. This is obvious. The C scrolls in the centre are held in position by a collar made in two pieces and riveted through. The tops of the pilasters are finished off with cast-iron knobs. The tops of the palings (usually called railings—a rail is a horizontal bar, not a vertical one) have been forged separately and screwed on to the tenons forged on the uprights. The lower ends of these uprights have been left rough and leaded into the stone base. The appearance of the work is greatly improved by moulded spikes and leafy arrows alternately placed along the tops. As J. de Wolf Addison says: "Craft may be practised without art and still serve its purpose, but an alliance of the two is a means of giving pleasure as well as serving utility." The photograph shown proves the truth of Addison's statement.

The fine pair of gates illustrated in Fig. 3, at Belton House, Grantham, Lincolnshire, are also typical of early eighteenth-century iron work. It should be noticed how the family coat of arms is embodied and forms an interesting portion of the design.

CHAPTER XI

MATERIALS USED IN HANDCRAFT WORK

CLASSIFICATION, DISTRIBUTION, DESCRIPTION.

Timbers—Mother of Pearl—Blue Pearl—Japanese Pearl—Ivory—Tortoise-shell.

"After all the trees have been cut down, it will be necessary for the arts to cease."—PALISSY (16th cent.).

TIMBER.

TIMBER is the product of "exogenous" (outward growing) trees, as distinct from the "endogenous" varieties (in which are included palms), growing or forming wood of inward growth. Practically the only exception to the general use of exogenous timber in woodworking is the use of palm, known more commonly as partridge and lacewood from its peculiar markings. Exogenous trees are again divided into two classes, hardwood and softwood trees respectively, broad and needle-leaved trees. This classification is botanical rather than commercial, for some woods of a hard texture, such as the yew, belong to the needle-leaved class. On the other hand, whitewood and poplar are soft in texture though belonging to the hardwood class botanically.

Chart I on the next page indicates the commercial and botanical classification of some timbers, which are, with the exception of yew, beech, and poplar, used in handcraft work.

Reference to Chart I will show the rather misleading classification of timbers, and this list could of course be extended indefinitely.

Effect of Climatic Conditions.—One of the most important factors in the growth of timber is climate. This accounts for the wide distribution of many types, for instance, pines, firs, and spruces are almost universally distributed, and it will be found upon examination of general conditions that differences in zones are compensated by altitude. Thus the northern pine is generally regarded as belonging to North Europe; in Northern Norway it grows at a height of 700 ft. above sea-level and 6500 ft. on the Sierra Nevada of Southern Spain. This feature of timber growth is further dealt with in Chart II.

CHART I SHOWING BOTANICAL AND COMMERCIAL CLASSIFICATION OF SOME TIMBERS.

Botanical Order	Common Name	Commercial Classification	Botanical Classification	Geographical Distribution.
Meliaceæ .	Mahogany: Cuba, Spanish, Honduras.	Hardwood.	Hardwood, Broad leaf.	British Honduras, West Indies, Nicaragua.
Taxineæ .	Yew.	Hardwood.	Softwood, Needle leaf.	Europe generally, Northern and Western Asia, and North Africa, California, and Japan.
Cupuliferæ .	Beech.	Hardwood.	Hardwood, Broad leaf.	Europe generally, America, Canada.
Populus .	Poplar.	Softwood.	Softwood, Broad leaf.	Europe generally, North America, Northern Asia, Northern Africa.
Pinus . .	Yellow Pine.	Softwood.	Softwood, Needle leaf.	North America.
Magnoliaceæ	American Whitewood.	Softwood.	Hardwood, Broad leaf.	Eastern North America.
Juglandaceæ	Black Walnut.	Hardwood.	Hardwood, Broad leaf.	Eastern North America.
Cupuliferæ .	Oak.	Hardwood.	Hardwood, Broad leaf.	Europe and the world generally.

CHART II ILLUSTRATING EFFECT OF CLIMATIC CONDITIONS ON THE GROWTH OF TIMBER TREES.

Order	Range of Temperature between Isotherms	Common Name	Botanical Term	Geographical Location (Range N. to S.)	Approx. Altitude above Sea-level	Zone
Coniferæ.	40° 30°	Northern Pine.	Pinus Sylvestris.	Northern Norway. Southern Spain. Etna.	3000 ft. 5600 ft. 7000 ft.	North Temperate.
Cupuliferæ	40° 20°	Beech.	Fagus Sylvatica.	64° N., Northern Europe. Balkans, 42° N. America.	Plains. 2000 ft. —	North Temperate.
Meliaceæ.	10°	Mahogany.	Swietenia Mahagoni.	Central America. Antilles. West Indies.	— — 1500 ft.	Sub-Tropical.
Salicaneæ.	40° 30°	Poplar.	Populus Nigra.	Central to Southern Europe. In Scotland.	— 1500 ft	North Temperate.

Reference to the above chart will show graphically the general distribution of some timbers, and illustrate the fact that most timbers are largely affected by particular climatic conditions. The quality of the soil is another important factor, the rich soils and humid atmosphere of tropical countries producing very hard, slow-growing, and well-figured and marked woods, whilst the temperate climates are favourable to the growth of moderately rapid-growing timber trees, which are, however, not so richly marked—with the exception of the oak—nor so hard in texture as the former. The situation of timber trees is another important factor affecting the quality of the wood, swampy land generally producing softer material, whilst rich soils, and especially those of tropical and sub-tropical countries, produce hard, close grained and richly grained woods. This general principle is especially applicable to trees belonging to the same order, as, for instance, Honduras mahogany, which ranges from very soft to moderately hard material. The tall, slender, and straight growth of trees in closely wooded land is a familiar feature, favouring an upward growth, and acting against a proper development of the branches. Those grown in open situations display the full characteristics of the tree to best advantage, as seen in our oaks, ashes, and elms. The quality of timber and its value from a commercial standpoint is also directly affected by its situation. If exposed to high winds an erratic growth is characteristic, and the wood exhibits considerably twisted grain, affecting its strength when submitted to tensile strain or compression. For this reason also branch-wood is not favourably regarded from a woodworker's standpoint. Australian timbers afford an interesting study relative to the effect of situation upon quality and growth. The sub tropical jungle forests with heavy undergrowth and humid atmosphere favour the growth of numerous grasses and palms in addition to trees of exceptional hardness, richness of colouring, and beauty of grain, including silky oak and Australian tulipwood; whilst the ironstone ridge belts in Western Australia favour the growth of a remarkably strong, though coarse timber, i.e. jarrah. The more temperate climate of New Zealand conduces to the growth of moderately hard timber, such as New Zealand or kauri pine.

Identification of Hard and Soft Woods: (1) By Transverse Section.—*Coniferous timbers*, such as the pines, exhibit clearly defined annual rings, the autumn growth being darker in colour than the inner ring or spring growth. There are no visible pores on a transverse section of the wood, but pith rays can be discerned under a good glass, very fine and numerous. Hard woods have distinct pores visible to the naked eye. When examined on transverse section, viewed under a microscope, these pores show definite groupings and geometrical arrangements in various timbers, the spring group showing best. Oak and beech afford interesting studies of this feature and of the pith and medullary rays which show as lines radiating from the medulla or pith. This is a general characteristic of many hard woods, and when cut, they constitute the silver grain, or figure, so valued in oak, and apparent in beech, although less conspicuous. Generally, botanical soft woods have no pronounced figure or markings, but there are exceptions, such as the yew, especially the burrs of this tree. For further study of this absorbing subject, the reader is recommended to various standard works on timber and trees given in the Bibliography at the end of the book.

(*2*) **By Leaves.**—Soft woods, such as the pines, firs, spruces, larches, and cedars, have needle-pointed leaves growing in small bunches or groups. Botanically also all coniferous trees are classed as soft woods, the cones being the medium of reproduction.

The leaf of the elm—a hardwood tree—has the edge serrated, and the leaves are arranged five upon a stem. The ash has a more pointed leaf, growing thirteen upon a stem, whilst the lime, alder, sycamore, beech, oak, cherry, etc., have each distinctive leaves, varying in shape and in their growth from a stem or twig. Some are spaced exactly opposite each other on the stem with a terminal leaflet as in the ash, whilst the birch, for example, exhibits an alternate spacing of the leaves on the stem at equal distances one from the other.

The study of flowers and seeds is also a fascinating pursuit. Flowers, male and female, fruit and seeds, ranging from the complicated reproductive process of coniferous trees to the simpler process of germination from seeds contained in an edible fruit, such as the apple, cherry, almond, etc., and the seeds contained in husks and shells, such as the horse-chestnut, acorn, and walnut, are from the instructor's standpoint at least, of especial interest for object lessons, introduced at intervals alternating with object lessons on familiar objects, tools, and processes. A few are suggested at the end of this chapter.

As is shown in the preceding chart, differences of latitude are compensated for by differences of altitude, countries near the equator frequently growing species of trees and other botanical growths at certain altitudes characteristic of northern latitudes. A typical example is the northern pine, which flourishes in Norway, Sweden, and Northern Europe generally, and also on the Sierra Nevada, Spain, the mean temperature for the year being almost identical in both cases. It does not, of course, necessarily follow that exactly similar growths will be found in places far apart with a similar mean yearly temperature, but the number of examples is at least striking.

With regard to differences of location, Mr. Dryer says: "The distance to which any species of plant may extend towards the poles, up a mountain side, or into any relatively cold region, depends upon the length and average temperature of the growing season. The distance to which any species of plant may extend towards the equator, or into any relatively hot region, depends upon the average temperature of a period about six weeks at the hottest time of the year."

Trees adapt themselves to conditions partly by variations of leaf surfaces; thus "deciduous" or leaf-shedding trees, including the beech, oak, plane, and sycamore, have broad horizontal leaves with a thin epidermis or skin which permits the maximum working power, viz. sustaining and nourishing the tree—whilst the growing season lasts, by exposure to the air.

Pines, on the other hand, with their spiky, needle-pointed leaves are

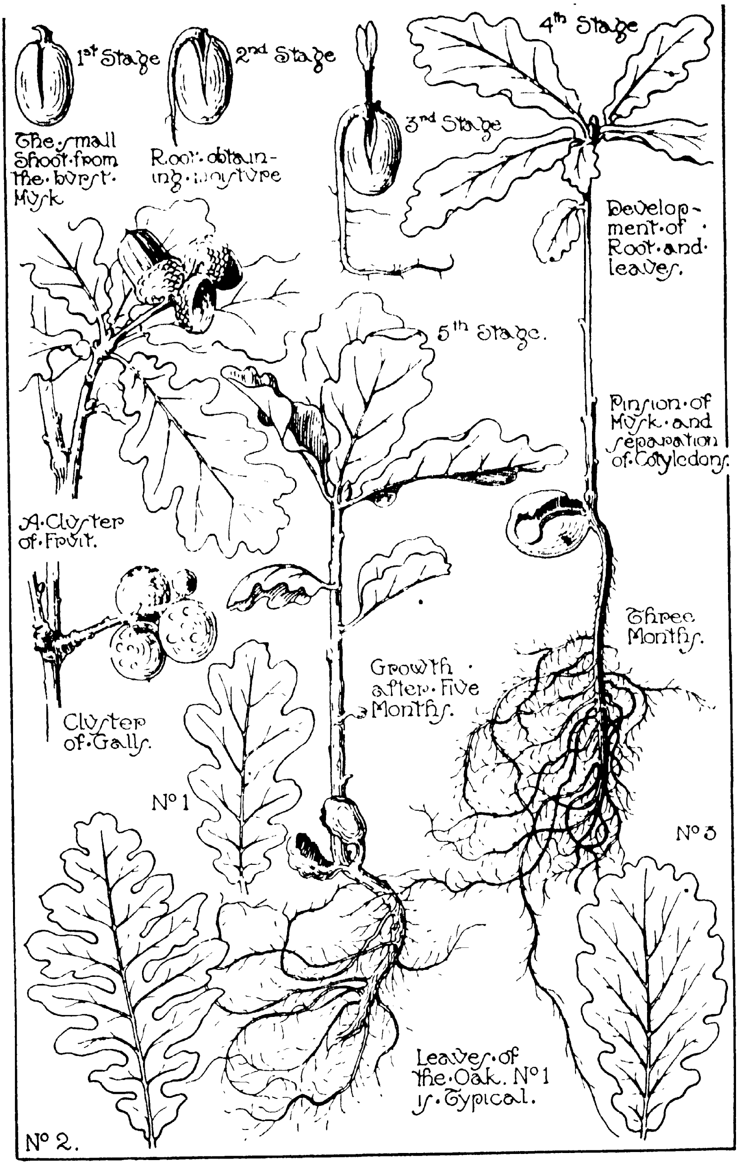

1st Stage
The small Shoot from the burst Husk
2nd Stage
Root obtaining moisture
3rd Stage
4th Stage
Development of Root and leaves.
5th Stage.
Pinion of Husk and separation of Cotyledons.
A Cluster of Fruit.
Cluster of Galls.
Three Months.
Growth after Five Months.
N° 1
N° 2.
N° 3
Leaves of the Oak. N° 1 is Typical.

FIG. 1.

peculiarly adapted to resist drought, by virtue of the small aggregate leaf surface exposed. In tropical countries atmospheric evaporation is a considerable factor; the majority of the growths are evergreen, and new leaves appear before the old ones are shed in order to sustain the supply of nourishment to the tree.

The Growth of an Oak-tree.—An object lesson on the growth of an oak-tree could be given with the aid of large charcoal diagrams made preferably from the actual tree, leaves, etc., or from the drawings in Figs. 1 and 2 of this chapter. It will be readily seen that any number of familiar trees could be dealt with in this way, the oak, ash, plane, apple, and walnut-trees readily lending themselves to effective demonstration. For the purpose of object lessons, too much scientific data is not advisable, the chief aim is to arouse interest in botanical growths by indicating the main features of timber growth. The following data are suggested for a specimen object lesson, lasting some twenty or thirty minutes, the illustrations being prepared, as previously suggested, with charcoal on large sheets of white paper. To preserve these drawings for future use, they should be sprayed with a fixative and mounted upon millboards.

On Fig. 1 are shown various drawings illustrating some of the main characteristics of growth in oak-trees. An acorn is shown just after bursting with the small shoot coming towards the light, this of course occurring in the spring of the year. The next diagram shows the second stage with the shoot turned downwards in search of moisture and nourishment. In the third diagram the leaf shoot is illustrated, and coincident with this, the root has increased in size and also in the number of small or secondary roots, which act as feeders to the main root. The fourth stage, drawn from an actual specimen, shows main roots secondary and hair roots, each one of the latter feeding the secondary roots and by means of them the parent root. As the tree increases in age and size, the roots spread over a much larger surface in order to satisfy the increasing demands of the small tree. The woody substance is formed by the ascending juices in the spring growth, some of these being deposited upon the stem. The rising sap, or natural juices, finally reaches the branches and twigs, causing the buds to appear and finally burst into leaf, and in some cases flower. During the summer season the roots are constantly extending themselves in search of natural salts and elements, which are in turn conveyed through the various parts of the tree to the flowers and later to the fruit. The oak, it should be noted, has no bright definite flower—unlike most other seed-bearing trees. During the autumn after the fruit or seeds are mature a return of the sap and natural juices in a different form takes place; those have changed in some degree by atmospheric conditions and return in a less liquid form, forming a thick autumn layer of wood in their downward course. This can be clearly seen in most woods, darker in colour than the spring layer of the annual ring. Characteristic of the oak is "its system of extension," otherwise known as "ramification". New growths appear at right angles to existing twigs, hence the oak branches, practically at right angles to the parent growth, as shown in various diagrams in Fig. 2. The oak is

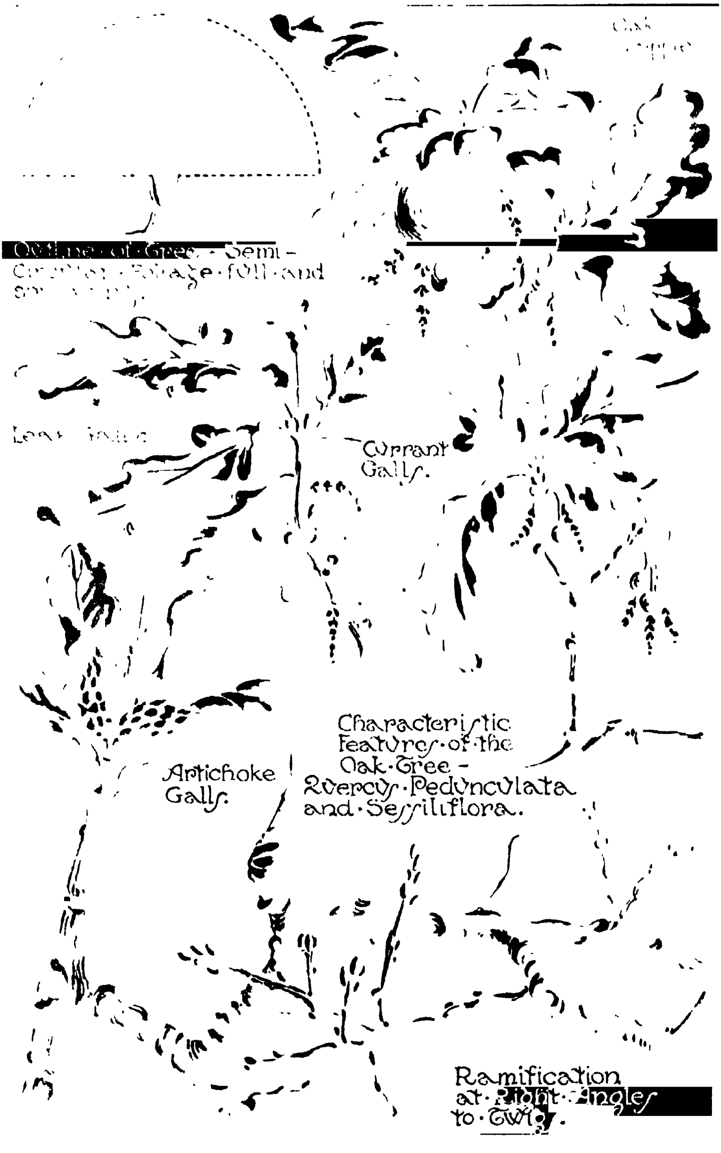

Oak Apples
Outline of Tree. – Semi-circular Foliage full and
Leaf
Currant Galls.
Characteristic Features of the Oak Tree – Quercus Pedunculata and Sessiliflora.
Artichoke Galls.
Ramification at Right Angles to Twig.

FIG. 2.—Characteristic detail of growth of the oak-tree

peculiarly liable to foreign growths, such as "cluster galls," shown in Fig. 2, oak apples, and currant galls, these being illustrated in Fig. 2.

Suggestions for object lessons on trees, etc. :—

1. General characteristics of timber trees :—
    Soft woods and hard woods. Introducing needle-pointed and broad leaves.
2. The growth of a tree from a seed :—
    (*a*) Pine.
    (*b*) Oak (see also Figs. 1 and 2).
3. Identification of trees from their barks.
4. ,, ,, ,, leaves.
5. ,, ,, ,, fruits.
6. ,, ,, ,, general outlines
    (*a*) in summer.
    (*b*) in winter.
7. Commercial value and uses of some English trees.—
    (*a*) The oak.
    (*b*) The beech.
    (*c*) The apple.
    (*d*) The cherry.
8 The seasoning of timber :—
    (*a*) Water seasoning.
    (*b*) Natural seasoning.
    (*c*) Second seasoning.
    (*d*) Desiccation or kiln drying.
9. The conversion of timber :—
    (*a*) Felling.
    (*b*) Lumbering.
    (*c*) Shipment of timber.
    (*d*) Cutting mill, machine and hand.
10. By-products of timber :—
    (*a*) Charcoal.
    (*b*) Tanning bark.
    (*c*) Natural oils—turpentine, resins, etc. :—
    (*d*) Paper pulp from timber.
    (*e*) Gum, rubber, etc., extraction of.
11. The formation of wood illustrated by the growth of.—
    (*a*) The plant.
    (*b*) The sapling.
    (*c*) The tree.
12. Geographical distribution of timber :—
    (*a*) Australia.
    (*b*) Russia.
    (*c*) United States.
    (*d*) England.

Shown by graph or chart illustrating ratio.

13. Trees as decorative media:—
    Box, holly, etc.
14. Afforestation and re-afforestation. Need for, and statistics of colonies and foreign countries.
15. Effect of climatic conditions upon the growth of timber.
    Timbers peculiar to certain zones.
    „ „ „ countries.
16. Leaves and their function.
    The pine needle leaf.
    Deciduous timber.
    Tropical growths.

Mother of Pearl, Japanese, and Blue Pearl are materials obtained from the shell of the pearl oyster, the former kind being so named because of its relation to the "pearl" which forms inside the shell and is almost detached from it. Pearl shell is composed of numerous layers of a crystalline carbonate of lime with but little animal matter. It is exceedingly hard and of a peculiarly lustrous colour. The best kinds of pearl oysters are found in the Indian Ocean, Red Sea, Gulf of California, etc., and Ceylon, where pearl fishing has been carried on for centuries. According to authorities on this subject, the pearl is produced by a small piece of grit or irritant entering the shell, which in time becomes covered with a secretion, forming a beautifully coloured stone-like gem of an oval shape. It was not until recent years that pearl shells were dealt in to any extent commercially; they were usually discarded after being opened, and the shores of some parts were strewn with these many feet deep. Now, however, they are an important branch of pearl fishing owing to the demand for pearl buttons, fancy articles, and inlaying material. For commercial purposes thick, good-coloured shells are much sought after. Important pearl fisheries lie to the North of Australia, the shells in that part being particularly suitable for commercial needs.

Ivory, the product of elephant tusks, is a beautiful material of peculiar milky colour used extensively for decorative purposes and especially for knife handles. An inferior substitute is walrus tusk, much used in place of the better and more costly material. Ivory in decorative woodwork is used chiefly in veneers, these being sawn by machinery. It can be rendered plastic by immersion in diluted acids which makes it transparent. The original colour can, however, be restored by a similar process. Old Italian craftwork shows fine examples of ivory inlay; it is most successful when used in small pieces with some woods as mosaic patterns. It can be fairly easily worked by means of saws, files, and glasspaper.

Tortoise-shell is a beautifully marked and coloured material from the shell of the tortoise. It is extensively used in fancy and ornamental turnery and cabinet work. Boule work of the Louis XV period is especially notable for the ornamental use of tortoise-shell. Added decorative effect is produced by painting the underside a vermilion colour, this showing through the lighter parts. The underside may also be gilded, by which means added brilliance of effect is obtained. Tortoise-shell can be advantageously employed in large masses, which is not the case with ivory and pearl. It should not be joined with square butt joints when connecting thin pieces, but spliced together, which effects a neater junction.

METALS.[1]

The word "metal" is derived from the Greek word "metallon" which means a pit or a mine, whence we get "metal". Technically it is a term applied to a number of elementary substances which possess, generally, certain well-defined characteristics, such as lustre, malleability, ductility, and fusibility.

The broad definition of a "metal" is as follows: A solid opaque body, possessing a peculiar lustre, fusibility, and conductivity.

Those which are most frequently employed in commerce and the arts are as follows:—

Common Name.	*Latin Name.*	*Symbol.*
Aluminium.		Al
Antimony.	Stibium	Sb
Bismuth.		Bi.
Cadmium.		Cd.
Chromium.		Cr.
Cobalt.		Co.
Copper.	Cuprum.	Cu.
Gold.	Aurum.	Au.
Iridium.		Ir.
Iron.	Ferrum.	Fe.
Lead.	Plumbum	Pb.
Magnesium.		Mg.
Manganese.		Mn
Mercury.	Hydrargyrum	Hg.
Nickel.		Ni.
Osmium.		Os.
Palladium.		Pd.
Platinum.		Pt.
Silver.	Argentum.	Ag.
Tantalum.		Ta.
Tin.	Stannum.	Sn.
Tungsten.	Wolframium.	W.
Zinc		Zn.

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[1] In the workshop the name "metal" is applied to both the pure metals and the alloys, and it is so used in these pages.

ALLOYS.

When two or more metals are caused permanently to unite the resulting mixture is called an *Alloy*. The term is also used for similar mixtures of metals and non-metals, such as iron and carbon = steel. The melting-point of an alloy is usually below that of the most easily fusible constituent.

Amalgam.—When mercury is one of the metals the mixture is generally known as an amalgam.

It is not necessary in this work to give the names of all the known alloys, as many of them are made for a special purpose or industry, and as these purposes are as varied as the number of alloys it is possible to make, and new combinations of metals are continually being invented, only the more common ones will be dealt with.

The following table gives the alloy and its composition:—

Alloys[1]. Their Names and Composition	Copper	Antimony	Aluminium	Tin	Zinc	Lead	Silver	Manganese	Nickel	Phosphorus	Iron	Gold	Carbon	Tungsten
Aluminium bronze .	95		5											
Brass . . .	65				35									
Britannia metal .	2	8		90										
Bronze . . .	90			10										
Delta metal . .	56				41·61	·72		·81		·013	·87			
Dutch metal . .	80				20									
German silver . .	46				20				34					
Gilding metal . .	83				17									
Gold (standard) . .	8·33											91·66		
„ solder (best) .	3						4½					12½		
Gunmetal . . .	9			1										
Manganese bronze .	60				15			25						
„ steel .								14			86			
Muntz metal . .	62			1	37									
Nickel steel . .								·85	25		74		·27	
Ormolu . . .	58			17	25									
Pewter . . .				82		18								
Phosphor bronze .	90			9¼						¾				
Silver (standard) .	7·5						92·5							
„ solder (best) .	22				14		64							
Spelter (for brazing) .	50				50									
Steel (for tools) . .											98¾		1¼	
„ (mild, for forging)											99·85		·15	
Tinman's solder .				2		1								
Tungsten steel . .								2½			91½		1½	4½
Type metal . .		3		12	16	64								

THE CHARACTERISTICS OF METALS AND ALLOYS.

It is their weight, lustre, malleability, conductivity, tenacity, ductility, fusibility, power of solidifying, hardness, and softness that make the metals so extremely useful. A short account of their properties is given below.

Weight.—It is not necessary to explain what is meant by the weight of a

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[1] All alloys vary within certain limits, but the above may be taken as typical.

PROPERTIES OF METALS.

RELATIVE POSITIONS IN DESCENDING ORDER.

Density or Specific Gravity.		Fusibility.	Tenacity	Conductivity for Electricity.	Conductivity for Heat	Malleability.	Albedo or Lustre	Ductility	Hardness.	Shrinkage
Osmium	22·4	Tungsten	Platinum	Silver	Silver	Gold	Silver	Iron	Iridium	See pages 127, 128
Iridium	22·1	Tantalum	Nickel steel	Copper	Copper	Silver	Tin	Copper	Cast iron	
Platinum	21·2	Osmium	Phosphor bronze	Gold	Aluminium	Aluminium	Nickel	Platinum	Osmium	
Gold	19·4	Iridium	Delta metal	Brass	Gold	Platinum	Steel	Silver	Wrought iron	
Tungsten	18·5	Chromium	Aluminium bronze	Aluminium	Brass	Copper	Antimony	Gold	Zinc	
Tantalum	16·5	Manganese	Manganese ,,	Cast steel	Zinc	Tin	Bismuth	Palladium	Phosphor bronze	
Mercury	13·6	Platinum	Nickel	Zinc	Tin	Lead	Iron	Nickel	Copper	
Palladium	11·3	Cobalt	Cast steel	Tin, pure	Wrought iron	Zinc	Zinc	Zinc	Silver	
Lead	11·3	Iron	Mild steel	Palladium	Lead	Iron	Lead	Tin	Gunmetal	
Silver	10·5	Palladium	Copper	Platinum	Platinum	Nickel	Brass	Aluminium	Brass	
Bismuth	9·8	Nickel	Muntz metal	Iron	Antimony	Antimony	Copper	Lead	Gold	
Nickel	8·9	Cast steel	Iron forged	Nickel	Bismuth				Lead	
Copper	8·8	Cast iron	Brass	Lead	Mercury				Tin	
Cadmium	8·6	Copper	Gunmetal	Aluminium bronze						
Cobalt	8·6	Gold	Gold	German silver						
Bronze	8·6	Brass	Silver	Antimony						
Brass	8·5	Silver	Aluminium forged	Manganese steel						
German silver	8·5	Magnesium	Copper cast	Mercury						
Manganese	8·1	Aluminium	Iron ,,	Bismuth						
Wrought iron	7·8	Antimony	Aluminium cast							
Cast steel	7·6	Zinc	Zinc cast							
Cast iron	7·4	Lead	Tin							
Tin	7·3	Cadmium	Lead							
Zinc	7·2	Bismuth	Bismuth							
Antimony	6·8	Tin	Antimony							
Chromium	6·7									
Aluminium	2·6									
Magnesium	1·75									

By courtesy of the "Metal Industry".

metal. But a useful figure in connexion with calculation of weights is the "Specific Gravity" or "Relative Density". This figure expresses the number of times any given volume of metal is heavier than an equal volume of water. For the exact conditions under which the comparison is made the reader is referred to a textbook of physics. Suffice it here to point out that when we say the relative density of iron or lead is 7·4 or 11·3 we mean iron is 7·4 and lead 11·3 times as heavy as water. An example is given of the use of this figure in calculating weight. It must be remembered that a cubic foot of water weighs 1000 oz. or 62½ lb. (nearly). An iron plate 6 × 4 ft. × 1 in. has in it 72 × 48 × 1 cub. in., i.e. $\frac{72 \times 48 \times 1}{1728} = 2$ cub. ft. This would weigh 2000 oz. or 125 lb. if it were water, and therefore since it is iron 125 × 7·4 = 925 lb.

If it had been lead the weight would have been 125 × 11·3. The same plate of cast steel would have weighed 125 × 7·8. See table on p. 125.

Lustre.—The power of reflecting the rays of light is possessed in a much higher degree by metals than by non-metallic substances. The metals and alloys which exhibit the greatest lustre for the longest time are those which are not quickly attacked by the oxygen and carbonic acid in the air and are sufficiently hard to receive a high polish. Gold and platinum have considerable lustre, because though not very hard they are not affected by the constituents of the atmosphere. Metals when highly polished are less easily tarnished because gases have then less tendency to condense on their surfaces.

Malleability is the property of being able to be beaten out by hammering, or the possessing of an internal mobility by which the shape may be altered by pressure without cracking or breaking. The malleability of a metal is affected by the temperature of the metal at the time of the hammering or working, also by the structure of the metal itself, or what is termed its "molecular condition". For example, a piece of gold or copper which has been hammered a great deal becomes hard or brittle, and if the hammering is continued it will eventually crack. But it will, however, regain its malleability on being heated to a certain degree; this heating is called annealing. The method of cooling is also important, as copper may be cooled from a red heat by being plunged into water, but steel by this method would become very hard, and to be softened steel must be heated to a red heat and then cooled very gradually. The crystalline or non-crystalline structure of the metal is also a factor to be considered. When crystalline a metal is not very malleable, but all malleable metals become hardened by hammering or working, so that they have to be annealed during the process of manufacture. A fibrous metal is generally very malleable and tenacious.

Some metals undergo changes of structure in process of time. Brass wire becomes brittle when kept in a state of tension, or in a damp storeroom; wrought-iron chains used in carrying loads have occasionally to be annealed to restore their malleability, as by the constant strain they become crystalline. Gold when hammered out into the form known as gold leaf is $\frac{1}{280000}$ part of an inch in thickness, and is semi-transparent, showing a green colour by transmitted light.

Conductivity is a power that metals possess of conducting heat and electricity. Metals that are the best conductors of heat are also the best conductors of electricity, and in both cases the conductivity is seriously impaired by the presence of even small quantities of other metals or impurities.

Tenacity is the property which enables a metal to withstand rupture by pulling. The influence of impurities in metals upon their tenacity is very variable. The enormous increase in tenacity produced by combining a small proportion of carbon with iron is well known, and may be contrasted with the relatively greater reduction in strength caused by a trace of bismuth in gold.

Ductility is the property of being able to be drawn out into fine wire or tubing. The ductility of metals is not in the exact ratio of their malleability; thus iron is very ductile and can be drawn into very fine wire, but it cannot, except in a very pure state, be rolled into such thin sheets as either copper or tin.

Fusibility is the property of becoming liquid when heated. Although the property of becoming liquid at high temperatures is not confined to the metals, it is one of those qualities which contribute very largely to their utility, for it enables the founder to produce a large number of objects from a given pattern, with only a small expenditure of time and labour. It also offers to the worker in metals a ready means of joining together in a durable manner the separate pieces of his work.

Solidification.—All metals solidify after fusion, and the temperature at which they change from the liquid to the solid state is known as the "freezing-point". Alloys in solidifying very often alter, as the heavier constituent separates, and consequently a metal is obtained which is not uniform in structure. It may be taken as a general rule that the melting-point of an alloy is below that of its most fusible constituent.

Contraction.—Nearly all metals contract in cooling. So when making patterns for articles that have to be cast, allowance must be made for the contraction or shrinkage; this depends to a large extent on their form and the distribution of the metal. Sand cores have a tendency to retard shrinkage; cylindrical or box-shaped articles shrink more in their length than in their diameter. The approximate contraction of various metals is as follows:—

Aluminium	$\frac{17}{64}$	in.	per foot
Bismuth	$\frac{5}{32}$	"	"
Brass, "heavy" . . .	$\frac{5}{32}$	"	"
Brass, "light" . . .	$\frac{3}{16}$	"	"
Bronze	$\frac{7}{32}$	"	"
Copper	$\frac{3}{16}$	"	"

Iron, cast	$\frac{3}{32}$ in. per foot
[1] Iron, wrought .	$\frac{3}{32}$,, ,,
Lead	$\frac{5}{16}$,, ,,
Steel " castings " . .	$\frac{3}{16}$,, ,,
Tin	$\frac{1}{4}$,, ,,
Zinc	$\frac{5}{16}$,, ,,

Hardness.—This is a relative term, and is the resistance offered by the molecules of a metal to their separation by the penetrating action of another body, and is affected considerably by the presence of impurities. The presence of another metal often tends to increase both the brittleness and hardness.

Softness.—This is also a relative term, but in many instances is a test of purity.

Aluminium.—A bluish-white but somewhat soft metal, very malleable, and takes a good polish. Can be cleaned by immersion in caustic potash and soda; unaffected by exposure to the atmosphere. Annealed only at a low temperature. Difficult to solder owing to insolubility of oxide, but can be welded by means of the oxy-acetylene blow pipe. There are many patent solders for soldering this metal.

Aluminium Bronze.—An alloy the colour of gold, is fairly malleable, and can be forged at a red heat; takes a beautiful polish if burnished. Cleaned by immersion in dipping acid; goes a rich brown when exposed to the atmosphere. Annealed by bringing to a bright red heat, cooling in air to a red, then plunging into water. Can be soft soldered after joint has been coppered by dipping in copper sulphate and touched with an iron rod, silver soldered, or brazed.

Antimony.—A bluish-white metal, very brittle; expands on solidifying. Used largely for type metal and alloying with other metals to give fine and sharp castings. A slight tap with a hammer will break an ingot of antimony, and the broken surface exhibits large shining facets.

Bismuth.—A pinkish-white metal, brittle, very diamagnetic; expands on solidifying. Used for alloying with other metals to lower the melting-point. Pewterer's solder, which is very fusible, is composed of lead, tin, and bismuth.

Brass.—A yellow metal, very malleable; takes a fine polish. Cleaned by immersion in dipping acid; turns black and green on exposure to atmosphere. Can be annealed by bringing slowly to a red heat and leaving to cool slowly in air; will break if moved when at a red heat. Can be soft soldered, silver soldered, brazed, and welded by the oxy-acetylene blowpipe.

Britannia Metal.—A nearly white metal, very malleable; takes a fine polish, and can be cleaned by immersion in strong soda or potash; darkens a very little on exposure to the atmosphere. Annealed by bringing to a temperature just above boiling water. Can only be soft soldered.

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[1] Although wrought iron is not cast, it contracts to about this extent after having been heated to a bright red. Some metals expand on cooling, and some nickel steel alloys neither contract nor expand by heating.

Bronze.—An alloy of a rich brown colour, malleable; takes a high polish. Can be cleaned by immersion in dipping acid; goes a dark brown and eventually green on exposure to atmosphere. Can be annealed by bringing carefully to a red heat and cooling slowly in air. Can be soft soldered, silver soldered, and brazed.

Cadmium.—A white metal with bluish tinge, soft. Not used largely for manufacturing purposes. Forms a component of one of the most fusible alloys, i.e. Wood's alloys; it is also alloyed with silver for electroplating.

Chromium.—A hard white metal very difficult to fuse. Used mostly for alloying with steel. Comparatively rare.

Cobalt.—A bluish-white metal, malleable, ductile, and tenacious, takes a high polish; unaffected by the atmosphere. Used in electroplating, seldom used in the manufacturing arts.

Copper.—A red metal, very malleable; takes a high polish, and can be cleaned by immersion in dipping acid; turns black and eventually green on exposure to the atmosphere. Can be annealed by bringing to a red heat and quenching in water, and can be soft soldered, silver soldered, brazed, and welded by the oxy-acetylene blowpipe.

Delta Metal.—A yellow malleable alloy; takes a fine polish. Can be cleaned by immersion in dipping acid; does not tarnish in moist air. Can be annealed by bringing to a red heat and cooling in air. Can be soft soldered, silver soldered, and brazed; can be forged at a red heat and is non-magnetic. Used largely in shipbuilding and marine engineering. Can be extruded.

Dutch Metal.—A bright yellow very malleable alloy; takes a high polish, and can be cleaned by immersion in dipping acid; turns black by exposure to the atmosphere. Can be annealed by bringing to a red heat and cooling in air. Can be soft soldered, silver soldered, and brazed. Used largely for imitation gilding, either in leaf or powder. Can be easily distinguished from real gold, as it is readily soluble in nitric acid.

German Silver.—A white or yellowish-white malleable alloy; takes a high polish. Can be cleaned by immersion in nitric acid and water and then in dipping acid, but tarnishes on exposure to the atmosphere. Can be annealed by bringing to a red heat and cooling in air. Can be soft-soldered, silver soldered, and brazed. Has a high electrical resistance.

Gilding Metal.—A light brown alloy. Used largely for articles that are afterwards gilt. Similar in properties to Dutch metal but not quite so malleable.

Gold.—A bright yellow metal extremely malleable; takes a bright polish, and is cleaned by immersion in a dip consisting of 2 parts by weight of hydrochloric acid and 1 part of nitric acid; this is called "aqua regia". Gold is not affected by the atmosphere. Can be annealed by bringing to a red heat and cooling in the air; must not be moved when at a red heat as it is liable to break. Can be soft soldered, and silver or gold soldered.

Gunmetal.—A light brown alloy. Generally used in the form of castings;

takes a high polish. Can be cleaned by immersion in dipping acid; turns black by exposure to air. Is annealed by bringing to a red heat and cooling in air. May be soft soldered, silver soldered, and brazed. Used largely for engineering purposes. Gilding metal matches this in colour, and can be bought in sheets, rods, etc.

Iridium.—A very hard, white, brittle metal, is very rare and difficult to fuse. Used mostly for scientific apparatus, and for objects to withstand very high temperatures. Cannot be crushed.

Iron, Wrought.—A greyish-white metal, malleable at all temperatures; takes a good polish. The scale can be removed by immersion in sulphuric acid 1 part, water 15 parts; rusts on exposure to the atmosphere and is eventually destroyed. Is annealed by bringing to a red heat and cooling in water. May be soft soldered, silver soldered, brazed, and welded either by the blacksmith's method or by the oxy-acetylene method; the former is the stronger.

Iron, Cast.—A grey metal very brittle and hard. Used only in the form of castings, is really the crude iron used largely for machinery. When cast iron is deprived of some of its carbon, thereby leaving it much softer and less brittle, it is called "malleable cast iron," and in this form it is often used instead of forgings, as it is cheaper.

Lead.—A grey malleable metal, very soft, marks paper; can only be brought to a dull polish. Should be cleaned by scraping or caustic soda; darkens slightly on exposure to the atmosphere, but after this it is permanent and no further change takes place. Is annealed by raising to the temperature of boiling water. May be soft soldered; is often joined by what is known as autogenous soldering or burning, especially for vessels used in chemical work. Wire and pipes can be made of lead by extrusion, squirting, or pressure.

Magnesium.—A silvery white metal. Burns with a very bright flame when heated. Used largely in pyrotechny and photography in the form of powder or ribbon; in the latter form it will light by the aid of a match. It is readily soluble in dilute hydrochloric acid and in dilute sulphuric acid.

Manganese.—A grey metal with a reddish tinge, very brittle. Used mostly for alloying with iron, copper, and nickel in the manufacture of very hard steel and mild steel; has the effect of toughening and generally improves the quality. Manganese is not usually used pure but in the form known as ferro-manganese.

Manganese Bronze.—A light brown alloy which takes a high polish and is malleable; sometimes called white bronze. Is cleaned by immersion in dipping acid; is not corroded by the action of sea-water. May be soft soldered, silver soldered, and brazed. Used largely for screw propellers and marine engineering owing to its great transverse strength, toughness, hardness, and the facility with which it can be cast sound. It is equal in strength to mild steel, and can be worked either hot or cold, but should be forged at a cherry-red heat.

Manganese Steel.—A greyish white metal; takes a good polish. Very strong and tough; toughness is improved by quenching in water from a white heat. Cannot be hardened like tool steel or welded; all shaping should be done while hot. Makes sound castings but contracts considerably.

Mercury or **Quicksilver.**—A silvery white metal, liquid at ordinary temperatures. Used in making amalgams and in scientific instruments.

Mild Steel.—A greyish-white metal, very malleable hot or cold, easily welded and forged into shape while hot; takes a good polish. Cannot be hardened or tempered like tool steel. Stronger than wrought iron, which it is gradually superseding for constructional purposes. Can be soft soldered, silver soldered, brazed, and welded either by the blacksmith's method or by the oxy-acetylene method; the former is the stronger.

Muntz Metal.—So called after the patentee, Sir G. F. Muntz of Birmingham. Really it is a malleable brass; takes a high polish. May be cleaned by immersion in dipping acid, and can be annealed and soldered like brass. It is sometimes called yellow metal sheathing, as it was used largely for covering the bottoms of wooden ships; it is now used for condenser tubes and marine work, as it is not affected by sea-water to any great extent. Can be forged at a red heat.

Nickel Steel.—A special steel of a white colour; has a fibrous structure; takes a high polish. Very strong, tough, has great power of resisting shocks, and has a higher elastic limit than carbon steel, and is not corroded so quickly by sea water. Can be welded if the proportion of nickel is not more than three per cent. Used largely for armour plates and crank shafts.

Nickel.—A brilliant white metal, malleable, ductile, tenacious, and can be welded; takes a high polish. Does not readily discolour on exposure to the atmosphere. Is cleaned by immersion in dilute nitric acid. Used largely as an alloy to produce a number of varieties of white metals which go under different names, but are mostly similar to German silver. It is also used largely in electroplating.

Ormolu.—The same as brass in all respects.

Osmium.—A bluish-white metal, very rare. Infusible except in the electric furnace. Used for filaments of electric lamps and alloyed with iridium for the points of gold pens.

Pewter.—A grey metal, very soft and malleable; takes a dull polish. Cleaned by polishing with some abrasive substance; turns a trifle darker but otherwise unaffected by the atmosphere. Can be soldered with a special solder which has a low fusing-point.

Phosphor Bronze.—A light brown metal; takes a high polish. Can be cleaned by immersion in dipping acid. Can be soft soldered, silver soldered, and brazed. Used largely for engineering purposes, mostly cast work; does not become crystalline under repeated shocks or jars; resists corrosion by sea-water, and it is difficult to obtain a spark from it, consequently it is used in the factories where explosives are made.

Palladium.—A white metal, very rare, untarnishable. Used in the manufacture of scientific instruments.

Platinum.—A white metal, very malleable; takes a high polish, unaffected by the atmosphere; coefficient of expansion the same as that of glass. It can only be dissolved in aqua regia; unaffected by single acids. It is used for the filaments in incandescent lamps and high temperature work in chemical processes. Can be welded at a red heat.

Silver.—The most perfect white of any metal; takes a high polish, very malleable. Cleaned by immersion in dilute sulphuric acid or in a solution of potassium cyanide and water; turns blue-black on exposure to the atmosphere, but is not corroded. Can be annealed by bringing to a dull red heat and cooling in air. May be soft soldered and silver soldered.

Silver Solder.—A white metal with a yellowish tinge. Used only for joining metals. Different grades have different melting-points, and vary in colour.

Solder (tinman's).—A white alloy. Used only for joining metals. By altering the proportions or adding bismuth or cadmium it can be made fusible at various temperatures. Used largely by tinsmiths and fused with the aid of a soldering iron, blow-lamp, bunsen burner, etc. Made in many qualities.

Spelter (used in brazing).—Zinc is often called spelter. A yellow or white metal, usually in the form of grains of various sizes. Used for joining metals, fused with the aid of a blowpipe.

Steels.—See pp. 172-174.

Tantalum.—A white metal, very rare, malleable. Used mostly for the filaments of electric lamps.

Tin.—A white metal, with a yellowish tinge, very malleable; takes a good polish. Can be cleaned by immersion in hydrochloric acid and water. With care it may be soft soldered. It is little affected by air at ordinary temperatures, and is therefore used largely for coating sheet iron to protect it from rust, as in culinary vessels.

Tin Plate.—This is small thin sheets of wrought iron or mild steel, which have been annealed, pickled, scoured bright, and dipped in molten tin on the top of which there is a quantity of melted tallow so that the sheets of metal pass through the melted tallow before entering the molten tin. The tallow is a flux and causes the tin to adhere to the metal sheets. The metal is then passed through rollers which squeeze off the excess tin, and they are then dried in clean sawdust.

Block tin, as it is called, or doubles, are iron or steel sheets that have been dipped twice, so having a thicker coat of tin on them, then planished with a polished hammer on a polished anvil. They are usually from 20-25 I.S.W.G.

Terne plates, which are duller in appearance than tinned plates, are plates dipped in a mixture of lead and tin.

The commercial names of tinned plates are very confusing, and the sizes vary. They are named by the size of the sheet, the quality, and thickness. For example, Common No. 1 is marked I.C. and the size is 14 × 10 in., and there are 225 sheets in a box weighing 108 lb.; the thickness is No. 30 I.S.W.G. Another

DXXXX, called four cross doubles, is No. 22 I.S.W.G.; size of sheet is 17 × 12½ in., or 17 × 25 in.

Tool Steel.—A greyish white metal, malleable, very strong and tough, takes a high polish. Can be cleaned by immersion in a mixture of nitric acid and lamp black. Oxidizes on exposure to the atmosphere. Is annealed by heating slowly to a dull red and cooling in hot sand or lime very gradually. May be soft soldered, silver soldered, and brazed. With care can be welded. Sometimes called crucible steel, cast steel, carbon tool steel.

Tungsten.—A grey metal, very rare, very hard. Used for alloying with steel to produce what are known as self-hardening steels.

Tungsten Steel.—A very hard steel. Used for cutting tools in engineering shops. Can be forged at a red heat and is hardened by bringing cutting edges to a white melting heat and cooling in a cold blast of air. Cutting edges last much longer and do more work than carbon tool steels.

Type Metal.—A grey metal, fairly soft. Used only for casting type for printing; expands on solidifying.

Zinc.—Sometimes called spelter. A bluish metal, fairly malleable at certain temperatures; takes a fair polish. May be cleaned by immersion in equal parts of nitric and sulphuric acids. Is annealed by warming with a bunsen burner, and can be soft soldered. Used largely for alloying with other metals and for the protection of iron from rust as in galvanizing.

THE EXTRACTION OF METALS.

The extraction of metals from their ores is usually described as metallurgy, and metallurgical chemistry is a special branch of chemical science which is usually conducted on a large scale at high temperatures.

Ores are generally mixed with earthy matters and often contain two or more metals in various forms up to a certain stage; they are all treated in a similar manner, that is, the ores have to go through some preliminary processes such as crushing, washing, dressing, and roasting, before being smelted. Advantage is also taken of the properties which are inherent in each particular metal to assist in the extraction. The methods used are broadly classified under the following headings:—

Smelting.—By mixing the ore with a flux and sometimes with fuel in various kinds of furnaces, and raising it to a high temperature by means of a heated blast of air sufficient to reduce the ore to a liquid condition and then pouring it into moulds.

The following metals can be extracted from their ores in this manner: copper, chromium, cobalt, lead, nickel, iron, magnesium, manganese, silver, tantalum, tin, tungsten.

Liquation.—In this process a metal that liquefies at a low temperature is separated from a more infusible one by taking advantage of their different melting or fusing-points, and the following metals can be obtained in this way: antimony, bismuth, lead, silver.

Distillation.—By heating certain ores the solid metals are driven off in the form of vapour; this is then condensed to a liquid or solid state. The following metals can be distilled from their ores: mercury, cadmium, zinc.

Amalgamation.—This is accomplished by bringing the ores into contact with mercury, which has an affinity for some metals. The resulting amalgam is then heated, which drives off the mercury in the form of vapour, leaving the metal behind. The following metals can be extracted in this way: gold, silver.

Electrolytic Methods.—This is where the metals are produced by fusing the ores in an electric furnace; this is owing to the great heat required to bring the metal to a fluid condition. The following metals are extracted in this way: aluminium, magnesium, tantalum, tungsten, chromium.

Wet Methods.—The ores in this process are dissolved in various acids or salts and are then precipitated by the addition of another acid, salt, or gas. The following metals can be extracted by this method: nickel, cobalt, gold, palladium, platinum, silver.

Lead and Zinc Method.—By fusing the ore with lead or zinc, with which they combine, then heating the alloys so that the lead and zinc are either liquated or volatilized, leaving the metal behind in a spongy mass which is then smelted in a special furnace to refine it. It is then poured into a mould. The following are treated in this manner: iridium, osmium, platinum.

Orthographic Projection.

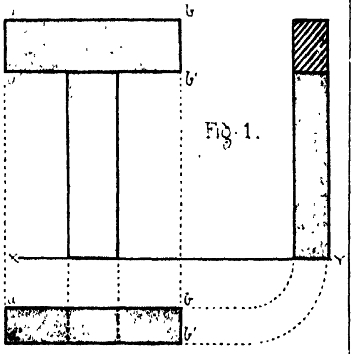


Fig. 1.

Definition.— Plan Elevation and Section in Geometrical or Right Projection.

Pictorial Projection.

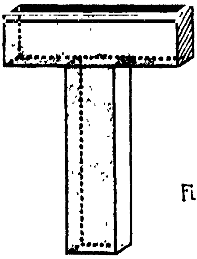


Fig. 2.

Definition.— A True Front Elevation with Thickness Lines Projected at a Convenient Angle Drawn Half Full Length.

Oblique Projection.

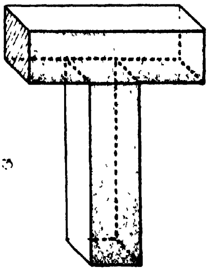
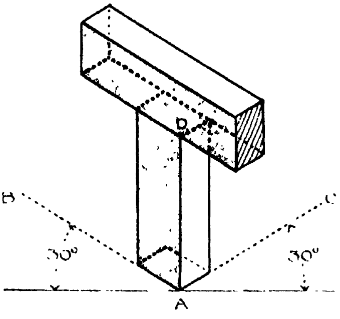


Fig. 3

Definition.— A True Front Elevation with Thickness Lines Projected Full Length at a Convenient Angle.

Isometric Projection.

Fig. 4.



Definition.— Length Breadth and Thickness Lines Drawn Parallel to Isometric Axes AB - AD and AC.

FIGS. 1, 2, 3, and 4.—Illustrations of various systems of projection.

CHAPTER XII

DRAWING, DESIGN, LETTERING, ETC.

APPLIED TO WOOD AND METAL WORK

THIS chapter is intended to deal chiefly with the special application of drawing to the practice of wood and metal work, and as an aid to the effective teaching and demonstrating of the above subjects. It is presumed that a knowledge of elementary practical plane and solid geometry, drawing from the cast (light and shade), freehand and model drawing has been acquired. The special kinds of drawing necessary to pupils when dealing with the subject of handcraft are as illustrated on plate opposite. Fig. 1 shows a tee joint in orthographic projection, meaning right projection, from *orthos* (right) and *gonia* (an angle), or the geometrical representation of solids upon a plane surface in front and side elevation, and plan. The representation may be full size, as in the case of a working drawing, as to scale. The procedure is exactly the same as in solid geometry. An elevation (see Fig. 1) is first drawn on an XY line, each point being numbered as *a*, *b* and *a'*, *b'*. Projectors are then dropped from these points below the XY line into the horizontal plane. The line *ab* is next drawn, then the thickness lines *aa* and *bb*. A side view is projected as shown, thus completing the three views required of the object. The next system—called pictorial projection (see Fig. 2)—is a simple method of obtaining an approximately correct pictorial view of a given object. An elevation is first drawn as for orthographic projection, then lines are projected from the elevation at any convenient angle (30° or 45° are most suitable), the real thickness of the object is divided, and one half is transferred to the thickness lines. The points obtained are then joined up and the back surface is represented. It should be noted that the latter lines are always parallel to their corresponding lines in the face side. Fig. 3 represents oblique projection; it differs from the former method only in one particular, viz. real lengths are marked on the projected lines instead of half-lengths. Angles of 30° and 45° are also suitable for this system. Compass lines and curves can be represented also when occurring in a model, involving the use of ordinates or guide lines. It is a satisfactory method for representing joints, small models, and constructive detail, and has the added advantage of showing three dimensions in a drawing, viz. length, width, and thickness. The use of the latter system is not recommended for large objects, having the disadvantage of giving an unpleasant tilted-up effect to the drawing. Various details are shown in this work, drawn as described. Isometric projection, from *isos* and *metric*, meaning equal measure, is particularly well suited for the representation of architectural and woodworking objects, these usually being composed of right-angled solids, or with their adjacent planes at right angles This system was invented by Professor Farish. The lines BA, DA, and CA constitute the isometric *axes*, and all lines coincident with a parallel to these axes are drawn true length upon the picture. To represent the front elevation of the tee piece in isometric projection, the width of the stem should be marked from the *regulating point* A. A perpendicular is then erected parallel to the axis DA; the lines of the head are then drawn parallel to BA and DA respectively; thickness lines of the object illustrated are drawn parallel to AC, then true lengths are marked upon them, and when connected they are of course parallel to the axis DA Curves, simple mouldings, and bevels may also be represented. The uses and limitations of the latter system are similar to those of oblique projection. **Working Drawings** constitute an important part of handcraft subjects; they are really an extended application of the principles embodied in the first example, and reference to the drawings in this book will suggest suitable arrangements of the views. **Perspective** is a branch of drawing knowledge based upon geometry, and it demands much study and practice in theoretical perspective shadow projection in order to become a proficient draughtsman. From the standpoint of teacher or student requiring perspective as an aid to effective expression of ideas or for purposes of graphic demonstration, a strictly accurate method is not absolutely essential. Architects' perspective is a much simpler system, and, although only approximately correct, it suffices for practical purposes. It may be divided into three kinds, of which the first is illustrated in Fig. 5, which also shows the key to the system. The scale is first decided upon, and then the elevation, side view, and plan may be drawn. Next a ground line is drawn (see key diagram), then the height or eye line at a distance of 5 ft. above the ground line, this representing the average height of a spectator's eye. The plan should then be transferred, the front corner touching the eye line, with the front line making an angle of 40° with it, the adjacent side of course subtending an angle of 50°. A station point is next decided, its distance from the GL depends upon the size of the object to be projected; it may be immediately below the nearest corner of the object, but not necessarily. Vanishing points must next be decided, the large diagram showing a suitable method of obtaining same; one line is drawn at an angle of 40° with the SP and another at 50° as shown. These are produced until they cut the HL. Angles of 30° and 60° may also be adopted, but the angle subtended by the vanishing lines should in all cases be 90°. The position of the legs is shown in the plan; a set square is placed on the drawing, touching one point of the plan and also the SP, then short projectors can be drawn until they cut the HL. From these points of intersection perpendiculars are dropped. The first to be so drawn is the

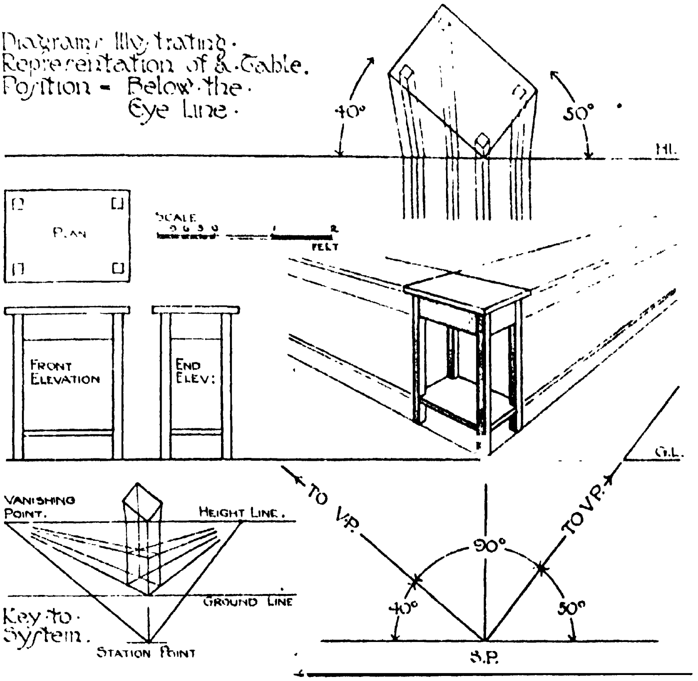
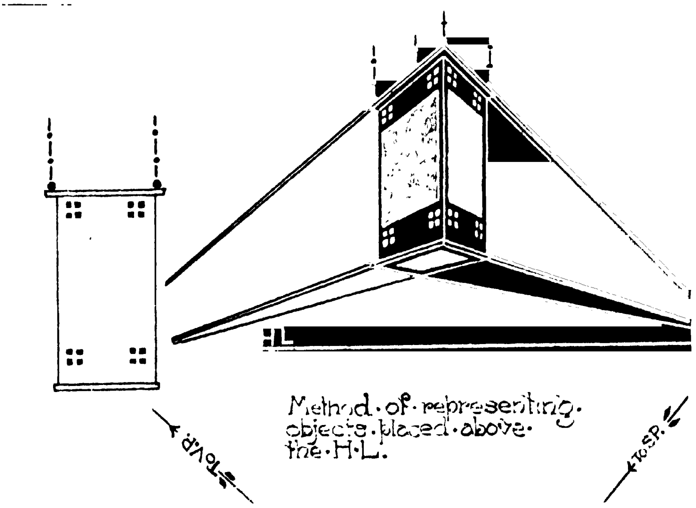


FIG. 5 —Diagrams illustrating method of showing objects in perspective when placed below the eye line



[illegible]

nearest line of the leg in plan; this must equal in length the elevation, and upon this *line* all heights for horizontal lines are measured. Both diagrams show the method of completing the drawing. Decorative features are added freehand; in the case of large curves ordinates may be employed for greater accuracy. It will be noticed from the views that all lines below the eye run in an upward direction, whilst those above the eye, as in Fig. 6, run downwards. A lantern is shown as an example in the latter diagram. The preparatory system is the same as that employed for the table. In both cases it is assumed that the distance of the spectator from the object is similar, therefore the nearest point in the plan coincides with a point on the HL. Projectors are drawn as before, and the necessary perpendiculars are drawn above instead of below the HL. The nearest point of the lantern should be about 7 ft. 6 in. from the SP, and a perpendicular raised from this provides the necessary line for preliminary measurements, which should also in this case be transferred from the elevation. If shading the completed line-drawing is desired, a good effect can be obtained by shading certain parts. The light has been considered in the diagrams to proceed from a position coincident with the left-hand VP. Those parts of the object farthest from the light are therefore strongly shaded, whilst the top receives a full measure of lighting and is left clear. The front of the table receives about half the light and is shaded as half-tone. Various media can be employed for this part of the work. With wash or colour drawings the washes should be made up in various depths of tone value; with pen and ink work the distance of the lines one from another is increased or decreased according as light or dark tones are required, as is also the case if pencils are used. The rendering of small objects in perspective is facilitated if a large scale is employed, as for example, the book-rest shown in Fig. 7. The real height is approximately 8 in.; this has been multiplied by 8, giving an assumed height of 5 ft. 4 in., which enables the object to be drawn by the method previously described. This is particularly well suited for the representation of small handcraft models, including handles, finger plates, bread platters, etc.

Design.—It is a matter of extreme difficulty to lay down certain formula for this elusive subject. Certain sizes of objects have been decided by custom, tradition, and fitness for a definite purpose, but proportion can be varied, and in itself is an important element of design. Models or objects with a bold, decided outline demand a corresponding boldness of decorative detail, whilst the lighter forms of craftwork are best suited to a dainty rendering of detail. This guiding principle is well exemplified by a comparison of Elizabethan wood or metal work with Sheraton's work of the eighteenth century. In the former, heavy proportions demand the use of large mouldings and carving with a peculiar freedom of treatment, whilst Sheraton's elegant proportions have mouldings and projections reduced to a minimum, with decorative inlaid work, light and dainty in design, or painted ornament of a similar character. Another important factor in design is the material employed. Oak, a strong grained wood of coarse texture, requires a heavier treatment than satinwood; fine moulded detail in the former is obscured by the character of the material, and conversely, satinwood or ebony, having an even tone or colour, readily lends itself to lighter proportions and ornament. Colour values have again a material bearing upon the success of a design; rosewood, ebony, holly, and oak harmonize well in most combinations, as do also Italian or American walnut and purplewood, ebony, snakewood, and satinwood. There are numerous pleasing colour combinations possible in the use of natur-

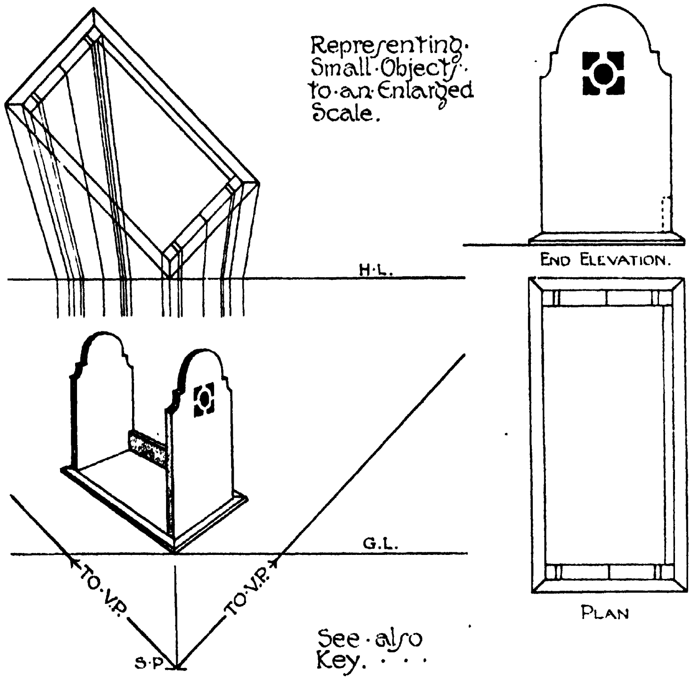


FIG. 7.—Method of representing small objects in perspective.

ally coloured woods alone, and the surest way to success is by experiment and careful observation with reference to harmony of colour. Ivory, tortoise-shell, and mother of pearl can be employed to advantage; the first material looks best when utilized in a dark groundwork for stencil effects. Tortoise-shell should be used in mass, and relieved by the use of silver or ebony, is very rich. The various varieties of pearl look best also in masses, with due regard to the beautiful colouring and lustre of the material. A study of historic work, and even prehistoric, cannot be too strongly urged; and to understand decorative craftwork.

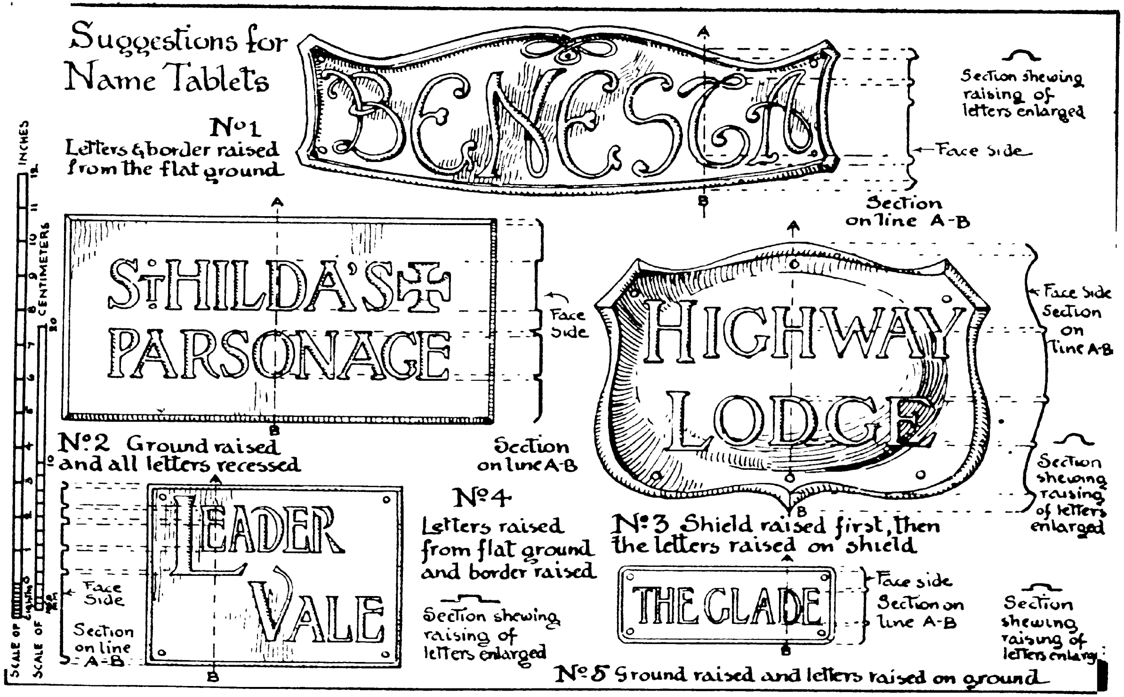

Suggestions for Name Tablets
No 1
Letters & border raised from the flat ground
BENESTA
A
B
Section shewing raising of letters enlarged
Face Side
Section on line A-B
St HILDA'S PARSONAGE
Face Side
Section on line A-B
No 2 Ground raised and all letters recessed
HIGHWAY LODGE
Face Side
Section on line A-B
Section shewing raising of letters enlarged
No 3 Shield raised first, then the letters raised on shield
LEADER VALE
Face Side
Section on line A-B
No 4
Letters raised from flat ground and border raised
Section shewing raising of letters enlarged
THE GLADE
Face side
Section on line A-B
Section shewing raising of letters enlarged
No 5 Ground raised and letters raised on ground
SCALE OF INCHES
SCALE OF CENTIMETERS
1
2
3
4
5
6
7
8
9
10
11
12
10
20

Fig. 7A.—Name tablets.

Illustrates various forms of lettering that are suitable for Name Tablet in hammered or repoussé metal, and how various effects are obtained by different treatment. These should be studied in conjunction with Fig. 11.

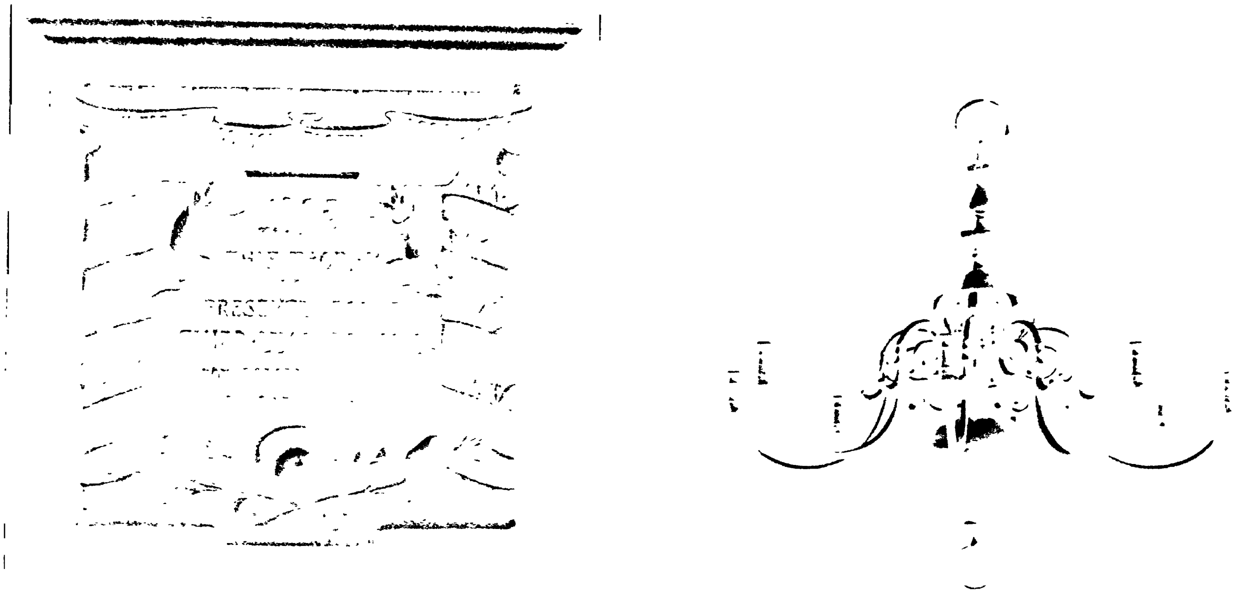
a study of history, customs, fashions, and politics is essential. The examples illustrated in various parts of the work show in some measure how traditional craftwork can be adapted to modern handcraft.

Lettering. First reference to handcraft deals chiefly with suitable imitation of printed characters on drawings. There are many excellent books published on this subject specially suited for students and teachers. Albrecht Durer type is well proportioned and tasteful in appearance; it has the added advantage of lending itself readily to geometrical construction, although this is not recommended unless a large exercise letter is being drawn. In one well-known antique book in the Victoria and Albert Museum at South Kensington, Albrecht Durer shows the constructions employed by him for the whole alphabet. Ancient Roman and mediaeval Italian is particularly good, and well repay study; this can be effected through the medium of old pictures, tablets, inlaid woodwork, and books.

For general handcraft purposes a square kind of lettering is best. Applied to working and scale drawings, headings in notebook and incidental descriptions, it is easy to space, and can with some little practice be quickly drawn. A good plan is to draw two lines parallel and about $\frac{1}{4}$ in. apart. These are then converted into squares with a space of $\frac{1}{16}$ in. between them. Such squares neatly filled with the letter (with the exception of I, which can be drawn with one stroke) give a precise and pleasing effect. Letters are then drawn in each square, and when spaced in this way completed words and sentences give a pleasing idea of good spacing and proportion. For class work, not more than one style should be adopted. The square lettering used upon many of the plates in this work can be reduced or enlarged in size according to the relative importance of the references, and have been found by the authors quite satisfactory for class work.

Figs. 8 to 12 of this chapter are some reproductions of artistic metalwork that have been made for various purposes and in different metals, and which in some cases are based on traditional styles. It will at once be seen how important are drawing, design, and lettering, in conjunction with mechanical processes and the knowledge of materials. They are examples of work that can be done by good craftsmen, and are modern. They show how material must govern design, and if this kind of work is to be maintained, it is evident that design drawing and lettering should be practised in conjunction with the actual work. In many cases the craftsman must be an artist. Teaching design in the abstract is of little use. It is useless to make a fine design for a wrought-iron entrance gate, and when the working drawing is made, and the work comes to be executed, it is found that it cannot be made owing to its prohibitive cost (caused by the length of time required to make it), or its faulty construction, or the impossibility of making and fixing in the metal required the forms as designed. The designer of metalwork must have knowledge of materials and technical processes, as well as of symbolical and conventional ornament. Many kinds of drawing, such as the drawing and colouring of plants, geometrical drawing, including development of surfaces, drawing with chalk, crayons, or charcoal on brown paper, or with charcoal, blue or red pencil on white paper, especially if of a large size or to a large scale, are useful in metalwork. The working out of workshop drawings from small coloured sketches is excellent practice, as it brings forward many points often overlooked in the small sketches. The working drawings should consist of full-sized drawings (where practicable) of each particular part and detail with the sizes in figures, as well as the constructive details (joints, etc.), which are most suitable for that particular part, and should show the name of the material to be used. If cast and turned work enter into the design, there would be the necessary patterns, core prints, core boxes, etc., to be drawn, showing the necessary allowances for shrinkage, turning, and fitting together, and the pieces that sometimes have to be added (and afterwards removed) for holding the work. Often during the manufacture, patterns or designs arise which in themselves can be utilized as decorative features, e.g. the rivets which hold the raised piece of metal on the finger plate (p. 67); only three are necessary, the rest could be dummies, but they form a decorative feature. The laps on the tin box on p. 69 are decorative as well as necessary.

All the articles shown in these pages have the names of the various metals of which they should be made; and on examination it will be found that there is a wide difference between what should be cast and what should be wrought, as a model that is designed for, and made in, wrought iron would not be suitable if made in cast iron. For instance, the cage handle illustrated on p. 107, though correct for wrought iron, would be wrong made of cast iron or wrought copper, and would cost a great deal more, because more difficult to make in these latter metals. It is not what is possible but what is proper and most suitable for the particular purpose. It is for many workers and students much easier to model a design for metalwork than to draw it, and it gives a better appreciation of form, bulk, and relief, than drawing ever can. It enters largely into the processes of blacksmithing (see p. 103), coppersmithing (see p. 84), silversmithing (see p. 89), casting, chasing, and embossing. A design that has been modelled, and is going to be made in metal, can be measured and gauged for the various heights of the relief, etc., which cannot be done with a drawing. It is thus more realistic, but it applies more particularly to cast, raised, and hammered work. Working from a model, there is less possibility of mistakes being made and consequently less waste of material. Many of the objects shown could be easily modelled the correct size, and the work made from the model without a drawing at all. The models Nos. 10, 11, 12 on p. 103, and No. 2 on Fig. 9, would have to be modelled, but in various ways and materials as described on p. 106. Models Nos. 6, 7, 8, 9, 10 on p. 78 could be modelled in a plastic material, then a plaster cast taken of them, and when suitable, such as Ch. IX, Fig. 6, Nos. 6, 10, 11, 12 on p. 103, they could be cast in brass or bronze. Letters could be treated in the same way, as letters are used largely for signs, shields, nameplates, etc., but good examples should be copied in the early stages. They could also be raised from thin sheet metal as shown in Fig. 8, or sunk and filled with coloured wax as shown in Fig. 11. A good practical exercise would be to draw a letter about 4, 5, or 6



(1) Embossed and chased copper tablet on wood back.

(2) Reproduction of a Dutch chandelier in brass.

FIG. 8.

inches high, transfer it by means of a tracing and pricking through with a pin to the modelling medium, model it and take a plaster cast from it, and from this to take a cast of the letter, strengthening it by means of galvanized iron wire. This would be a pattern from which a casting in metal could be made. This in turn could be filed up and finished, thus completing the letter from the drawing to the finished articles. Patterns for letters could also be made in wood.

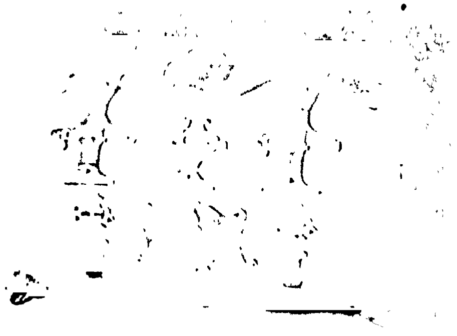


FIG. 10.—Casket covered with tooled painted and gilt leather and enriched with bronze mounts and enamelled crest.

Colours should also be considered when drawing and designing for decorative metalwork, as each metal has its own characteristic colour, and this can often be modified and altered by colouring. The methods are described on pp. 179-180. The arrangement of one metal with another is often dependent on the colour, and if we include enamelling, inlaying of another metal or of precious stones, etc., any arrangement of colour is possible, and highly artistic effects are obtained. The casket illustrated in Fig. 10 and the memorial tablet (Fig. 11) are good examples of metalwork in which colour is an important feature. The casket itself is made of mahogany and covered with richly tooled, painted, and gilt leather, mounted with bronze feet, handles, hinges, and lock. In the centre of the lid there is a heraldic crest in translucent enamel, thus forming a work of art in which colour is predominant. The memorial tablet (Fig. 11) is of copper on a green marble base. It is embossed, and the stars are of silver inlaid. Some of the lettering is raised from the back, and the rest is sunk and filled in with red wax of a tint different from the surrounding copper. The whole is emblematical of the man and his life.

The trophy in Fig. 8 (1) is of hammered copper mounted on a wood base, and the design is based on the apparatus—the net and posts and the ball used in the game—and the laurel or bay-leaf branches which were used by the ancients for making wreaths for the victors. The brass chandelier, or if fitted for the electric light, an electrolier, is a reproduction of an eighteenth-century Dutch one, and is made entirely of cast and turned brass, Fig. 8 (2).

The lock plates, see Fig. 9 (1), made of wrought steel, with forged handles, pierced and applied ornament, are of a design based on Elizabethan work of the sixteenth century. They are polished and have been hammered in the making and the marks have not been taken out. These give the metal a rich appearance.

The fire implements and stand, Fig. 9 (2), or as they are sometimes called, a fireside companion, are also of polished steel, and the dragons' heads have been forged and chiselled. This is modern; it could be made of wrought and cast brass, or of wrought and cast copper, or with cast and wrought copper handles and steel reins. This last treatment would be very effective. Examples are given on page 103.

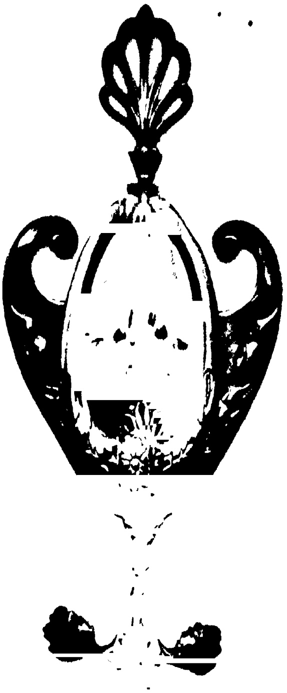
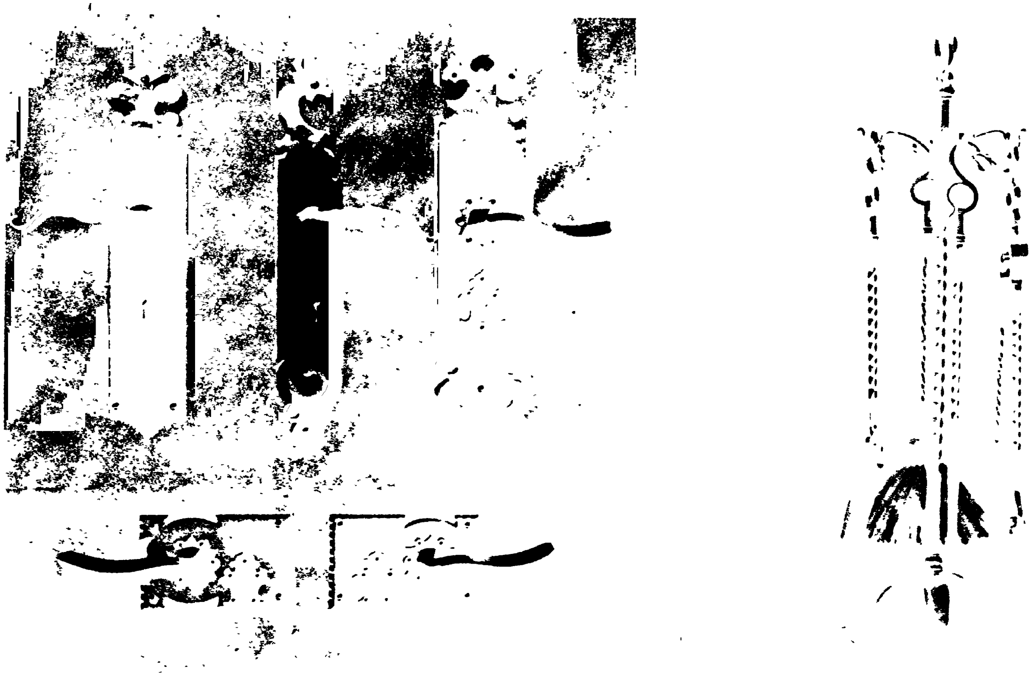


FIG. 11A.—Adam Door Knocker, Percy House, Great Portland Street. (Now destroyed.)

The wrought-iron pediment of a gate shown in Fig. 12 (1) is a good example, not too intricate, of the use of natural forms treated in a conventional manner, and suitable for the material. Each small leaf has been welded separately on to each stem. They are all modelled, and as they vary in thickness, they have been forged from bar iron and shaped while hot. The larger leaves are cut from thick plate and modelled while hot, and then welded on to the scrolls, with the exception of the two end ones on the bottom bar.

The illustration, Fig 12 (2), is of a wrought-iron grille of quite a different character. This is based on the palm leaf, and treated conventionally.

The very handsome polished brass door knocker (Fig 11A) from Percy House, Great Portland Street (now demolished), is a good example of practical design, being most suitable for its purpose, and the material from which it is made. It is is neither too heavy, nor overloaded with ornament, and it can easily be cleaned. This is an example of eighteenth-century work.



(1) Lock plates and handles of polished steel.

(2) A fireside companion in polished steel.

Fig. 9.

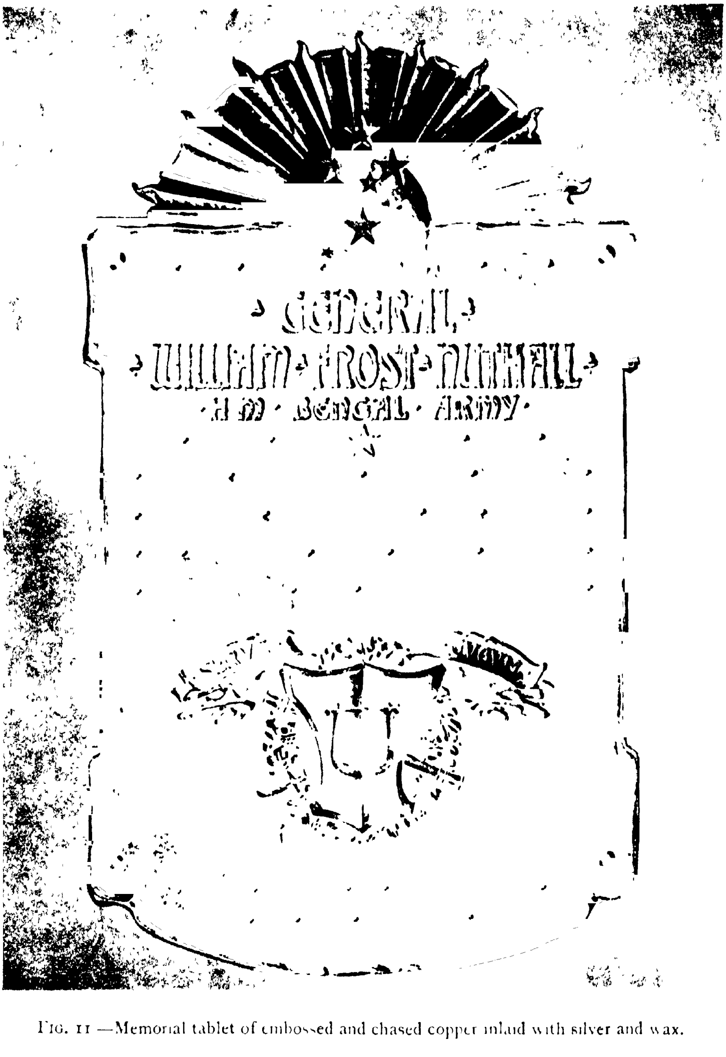
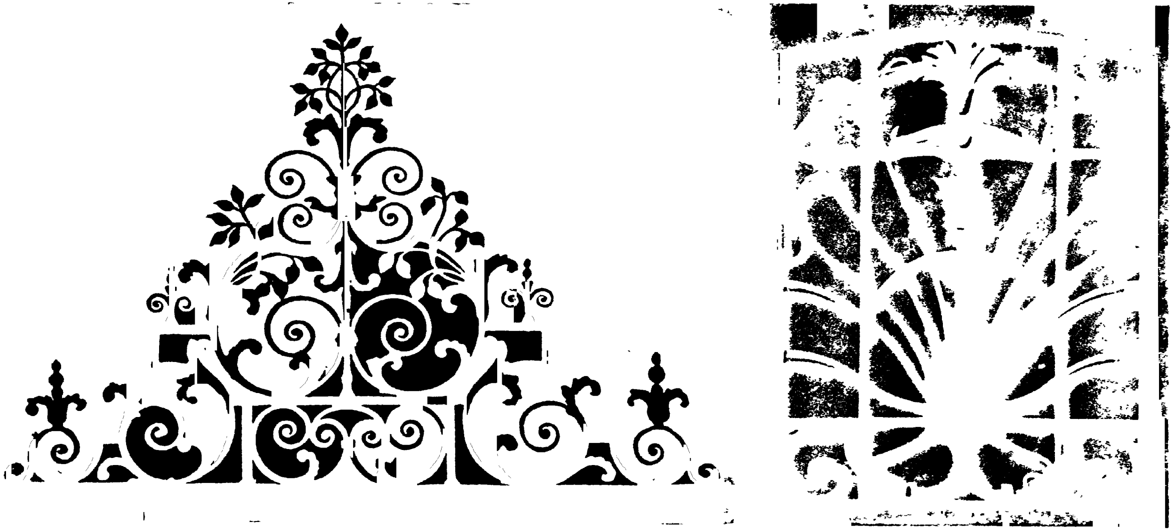


FIG. 11 —Memorial tablet of embossed and chased copper inlaid with silver and wax.



(1) Wrought-iron pediment for a gate.

(2) Wrought-iron grille.

Fig. 12.

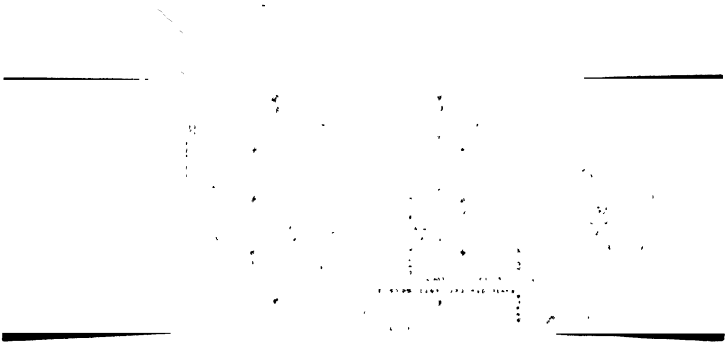


Fig. 1.—Part of a Dutch cabinet showing marquetried floral ornament.

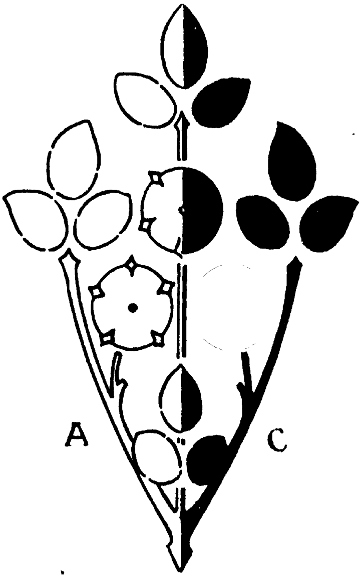


Fig. 2.—Diagram illustrating method of inlaying leaves, etc.

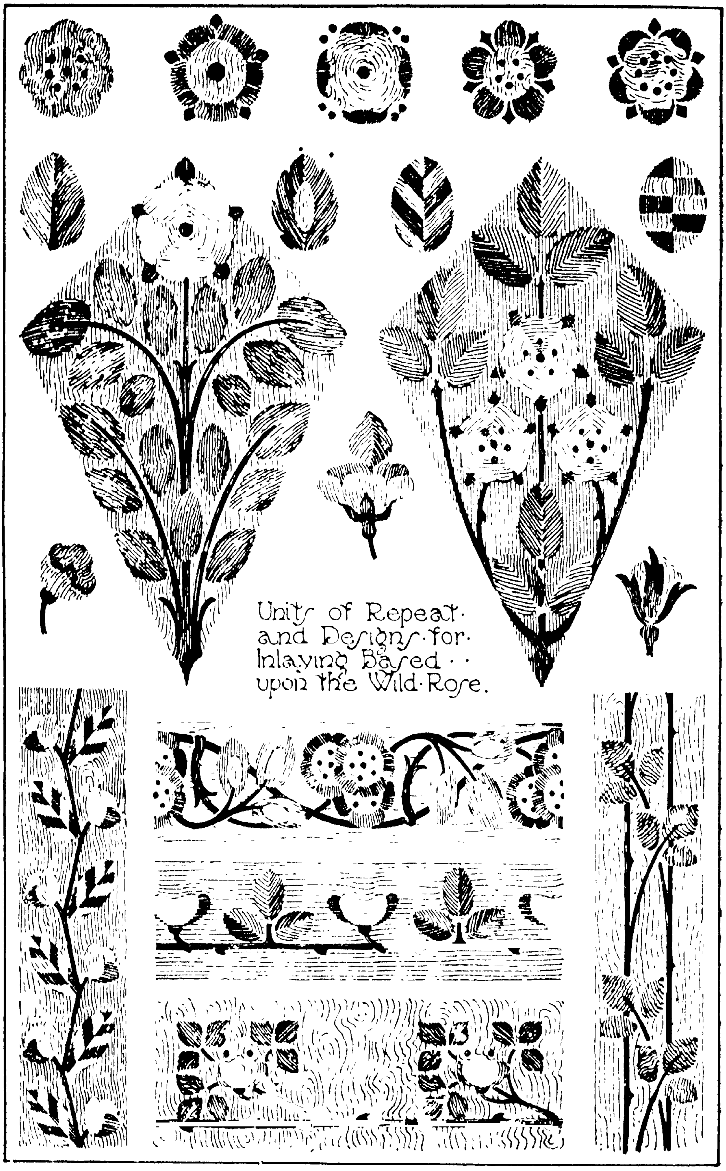
CHAPTER XIII

DECORATIVE PROCESSES

IN WOOD AND METAL WORK

"Art is man added to nature."—BACON

INLAYING is an art of great antiquity. The term may be regarded as equivalent to the Latin "interserere," to insert. Inlaying proper consists of cutting out thin pieces of wood, veneer, or other material to correspond with the units of a certain design. These are marked upon the groundwork and cut with chisels and gouges This leaves cavities into which the prepared units of the design are "inserted" or "laid in" the groundwork, being fixed with glue or other adhesive medium. The term "marquetry" is often confused with "inlaying," but the two processes are totally distinct. Marquetry comes from the French word "marqueter," hence marqueterie, and originally meant to spot or mark. The latter term is applied to decorative work where six or more sheets of veneer are temporarily fixed together and cut simultaneously to a design with a special saw and implement called a "donkey". The various pieces are then interchanged from the different layers in order to effect the necessary contrast of colour and are then glued down to a sheet of paper to complete the whole design A good example of inlaying is shown in the frontispiece at the head of the mirror frame. From this it can clearly be seen that the design must be composed of separate and distinct units A characteristic example of marquetry from a Dutch cabinet is shown in Fig. 1. A comparison of the two examples shows the fact that with the former process stencil effects are best and in the latter continuous designs of floral and symbolical devices can be executed The inlaying in the frontispiece is also an excellent object lesson in the handling of material, and the limitations of design imposed by the use of a brittle material. It is an axiom of good inlay design that the various units of an inlayed pattern should be of such a shape as to permit of easy handling during the processes of cutting and shaping previous to glueing in. Obviously this prevents the use of composite parts designed with a too close resemblance to the natural motif, when it is intertwining stems, sharply curved stalks, leaves, etc. This principle will be better understood by reference to the illustration, Fig. 3, here are shown some inlaying designs based upon the wild rose. A certain stiffness of effect is inevitable, but considerable charm can be produced by good grouping and colour harmonies with natural woods. To produce either of the panel centres shown, the design is


Units of Repeat and Designs for Inlaying Based upon the Wild Rose.

FIG, 3.--Various designs for inlaying based upon the "Wild Rose".

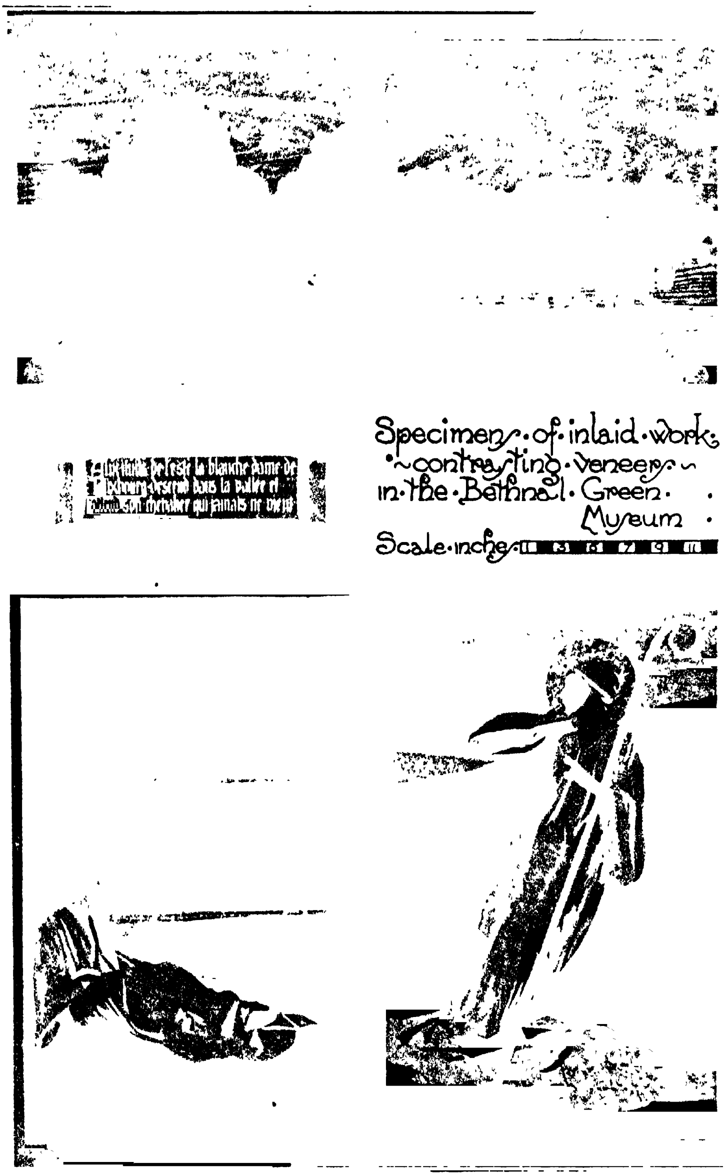

Specimens · of · inlaid · work · contrasting · veneers · in · the · Bethnal · Green · Museum ·
Scale · inches

FIG. 4.—Various specimens of pictorial overlaying from Bethnal Green Museum.

first prepared on cartridge paper and glued down to the groundwork or panel, see A, Fig. 2. Tracings are then made of each unit, i.e. stems, flowers, and leaves, these being glued down to suitably coloured veneer. In the case of the flowers, one tracing serves for three thicknesses of veneer, and so on with leaves and stalks These are cut out with a small hand fret-saw (see illustration Ch XVI, f. 8 (1), used in conjunction with a small cutting board or a vice as illustrated in Ch XVI, f 15. They should be cut "outside the line," that is, so as to leave the pencil mark upon the unit, and the cavities upon the ground are cut with gouges first "inside the line" Each piece should be tried and fitted if necessary before glueing is proceeded with. C in Fig. 2 illustrates the design when the main units of the design have been inlaid. The spots and small diamond shapes are best done with a small square awl hole and chisel, afterwards filled with a coloured composition. Although generally termed inlaying, the examples shown in Fig. 4, are really "overlaid". These are admirable examples from the Bethnal Green Museum, illustrating the possibilities of good decorative work in woods and veneers Richness of effect is obtained by the careful selection of material, with due regard to colour and the natural markings of the wood The executive processes attached to work of this type vary from those previously described. The general principle is to first lay a piece of veneer upon the groundwork (this is described under the heading of veneering in another part of this work) The design is glued down to the groundwork and a tracing is taken of each unit, these being glued down to pieces of veneer and cut out with a fret-saw As in the process of inlaying, each unit should be cut outside the line and the groundwork outline just cut away The design is commenced at a corner and laid down piece by piece until the whole is completed Inlaying of yet another kind is shown in Fig 5 This is a fine example of Persian craftsmanship and a beautiful specimen of design work. In the execution of this and similar work the groundwork was covered with a preparation of mastic—a kind of lacquer—and the prepared units were embedded until the whole box was incrusted with mother of pearl or ivory. It was then allowed to stand until thoroughly hardened, when it was levelled down, the finished surface having the appearance of inlaid work The drawback to this process is that the mastic has a tendency to peel away from the groundwork, as can be seen in the photograph. The original coffer is in the Victoria and Albert Museum There are various interesting references to inlaying in classical literature. Chests mentioned by Homer were ornamented with inlaid work of precious metals and ivory. Vitruvius and Pliny also refer to inlaying, using the word "cerostrata," meaning inlaid with horn and wax. In Book 23 of the "Odyssey" Ulysses describes to Penelope the bridal bed in the following terms. "Beginning from this head post, I wrought at the bedstead till I had finished it, and made it fair with inlaid work of gold and of silver, and of ivory" A Biblical reference to inlaying is found in 1 Kings x. 18: "Moreover the king made a great throne of ivory and overlaid it with the best gold". There are several other references to this and other arts in the Bible.

Various London museums and the Louvre display specimens of inlaying of ancient Assyrian and Egyptian origin, remarkable both for ingenuity of design and perfection of execution. Metal, ebony, and ivory were the chief media used. Processes connected with handcraft lessons, either constructional or decorative, must necessarily be simple and within the range of a boy's ability. Whilst, however, strict limitations to the practical side are imposed by a pupil's capacity and physical strength, the educational or culture value is practically unlimited. Lessons on the history or development of inlaying can be devised, and the importance attached to this art in ancient times can be discussed through the medium of classic literature. The style of inlaying best suited to the needs of handcraft centres is that in which a definite unit is taken and arranged into a design. Thus in Fig. 6 a leaf is made by the simple action of two gouge cuts. The boys should be limited to the use of a certain number of units and instructed to arrange them into a simple design. Reference to Fig. 6 will show two simple treatments. When the design is completed and drawn in outline, it should be pasted down to the work in hand. The same gouge is used to cut the units in the groundwork, and when it is placed in position it should be struck smartly with the hand. The inside can then be easily removed with a small chisel, leaving cavities for the reception of the leaf units. Further applications of this process embodying various degrees of manipulative skill are illustrated in the woodwork models.

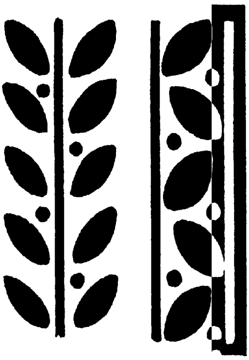


FIG. 6.—Gouge patterns.

Another simple method of decorating the edges of handcraft models is that illustrated in frontispiece. This is a traditional type of decoration, introduced during the period of Queen Anne. It is easy to manipulate and refined in appearance. It is capable of many variations and is proceeded with as follows: Two pieces of wood of contrasting colours and $\frac{3}{16}$ in. thick are gauged and planed up to thickness, the end of each piece is then planed across and strips gauged and cut from each piece, the edges being smoothed with a finely set plane. They are then glued down alternately to a piece of knife-cut veneer, and when dry the edge is planed, and strips gauged off as indicated by the dotted lines in diagram Fig. 7. In each of these designs it is necessary to work a small rebate, into which the "mosaic" inlay is glued and levelled off. This process is further

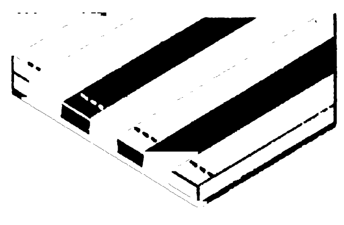


FIG. 7.—Building mosaic edging.

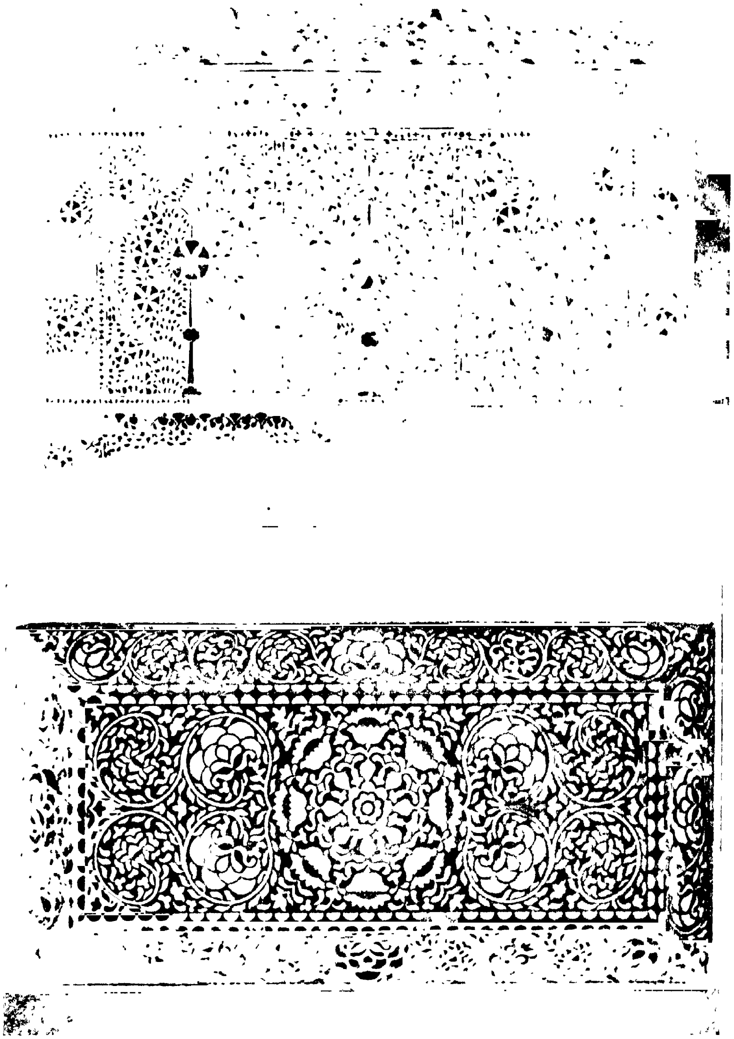


FIG. 5.—Fine examples of Eastern inlaying. Mother of pearl and mastic.

illustrated on p. 50. A few good specimens of mosaic stringings, which can be purchased at most veneer stores, are illustrated on p. 53. These are inlaid as shown on p. 54, and the method by which this is effected is as follows: A scratch stock (see Fig. 8) is first prepared. A represents the stock, B is the stock or butt piece, and is connected to the stock by a bolt passed through A and B. The butterfly nut C is loosened and B can then be pushed along the required distance from the edge of cutter E. The sectional view shows the stock with convex edge fitting into the concave edge of the butt piece or stop. The cutter E is made from $\frac{1}{16}$ in. steel, the edge sharpened like a chisel, and then a burr is produced as with an ordinary scraper. The scratch stock is operated by pressing the end of B against the edge of the material, drawing the instrument to and fro to form a channel into which are glued the stringings, and when dry they are levelled with the groundwork. Various other applications of this process involving slight variations of practice are dealt with as they occur in connexion with the models. The following are given as examples of combinations of colour in natural woods for purposes of inlaying :—

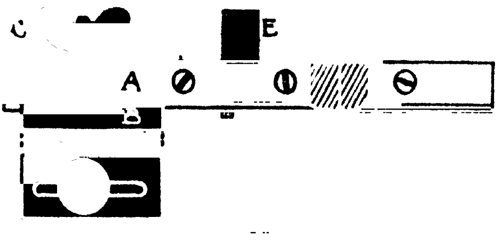


FIG. 8 —Diagrams illustrating a scratch stock

For oak groundworks the following woods give pleasing effects :—

Green and brown ebony. Various varieties of rosewoods, holly, chestnut, Italian and American walnut, and cocos wood, a species of ebony.

For Italian or American walnut groundworks :—

Brown oak, the various varieties of ebony and rosewoods, holly, pear, box, and purple wood.

For rosewood groundworks :—

Brown oak, ebony, purple, ivory, and holly.

Other materials used for inlaying include mother of pearl, blue and Japanese pearl, ivory, and various metals, all of which can be judiciously combined with the majority of the preceding woods. All these demand certain processes not previously dealt with. Pearl is a very brittle substance and extremely hard, hence one thickness only can be cut at a time, and the best plan is to trace the desired shapes on to the pearl and then to fix it in the jaws of a parallel vice (see diagram Ch. XVI, f. 15) A small fret saw frame (see Ch. XVI, f. 8 (1)) should be used to cut the pearl, held with the blade horizontal A little soap rubbed on the blade facilitates working, and if necessary the pieces should be regulated with a fine cut file. Before they are glued in, the pieces should be roughened with the end of a file in order to assist the adhesion of the glue. Ivory is treated in a similar manner, and is also cut, one or more thicknesses, as described above. Metal for inlaying should be about $\frac{1}{32}$ in. thick, and is also cut with fret saws as described, the underside being picked with a sharp point to assist adhesion. A small quantity of Venice turpentine or garlic added to glue acts chemically upon metallic surfaces, removing all traces of grease, and effects a much stronger joint. Mother of pearl is best when treated in masses for decoration, thus obtaining the full effect of its charming colours and varying shades. Ivory is best for spotted or mosaic decoration, and the use of metal is practically restricted to small escutcheons and enrichments.

Wax Inlaying.—This is another traditional type of decoration, rather unjustly abused in some quarters. Theoretically the application of wax inlaying may be wrong, it being contended that its composition is liable to shrink and fall out. In actual practice, however, a better state of things occurs, as is evinced by a fine French cabinet (period sixteenth century) in the Edinburgh Museum. For this example a free treatment of design is possible, there being practically no limitation to the use of the material, as is the case when inlaying wood. The design is cut out with a vee tool and gouges, and the cavities filled with a composition of wax, dry colour, and resin. The latter acts as a hardening element. The three media are melted and well mixed together, and the mixture is then put into the grooves with a piece of stick Previous to the insertion of the wax, the wood should be given a coating of ordinary French polish which prevents discoloration of the groundwork and a ragged effect in the fine lines owing to the composition soaking into the end grain. A design can be executed in one or more colours, care being taken not to allow them to merge one in the other where they join. The composition is dry half an hour or so after its application, and the superfluous composition can be removed with a steel scraper. Colour combinations for this process include reds, blues, blacks, and greens for oak ; yellows, blues, or greens for mahogany. Stronger contrasts of colour can be effected with wax inlaying, and generally speaking, the tone of natural wood accentuated can be utilized as colour schemes. Various applications of this process are shown on pp. 33 and 27. A combination of wax and veneer inlaying is also an effective treatment (see Fig. 6 on p. 50). Punch work filled with this preparation is particularly suitable for young pupils, giving a deal of scope for ingenuity in design, and it is particularly easy to manipulate.

RECESSING.—This type of decoration, a familiar feature of Jacobean work, is not now used to the extent it deserves. There has been no noteworthy example of this art in England since the seventeenth century, nor abroad, where it flourished about the same time. Switzerland, Germany, and Scandinavia all excelled in the practice of this art, and the museums show some excellent examples of furniture decorated with this process. The details of a fine Tyrolean cabinet in the Victoria and Albert Museum are illustrated in Fig. 9, from which it will be seen that the whole outline is simply vee tooled and then recessed. The veins of the leaves are executed with one cut of the vee tool. Simple

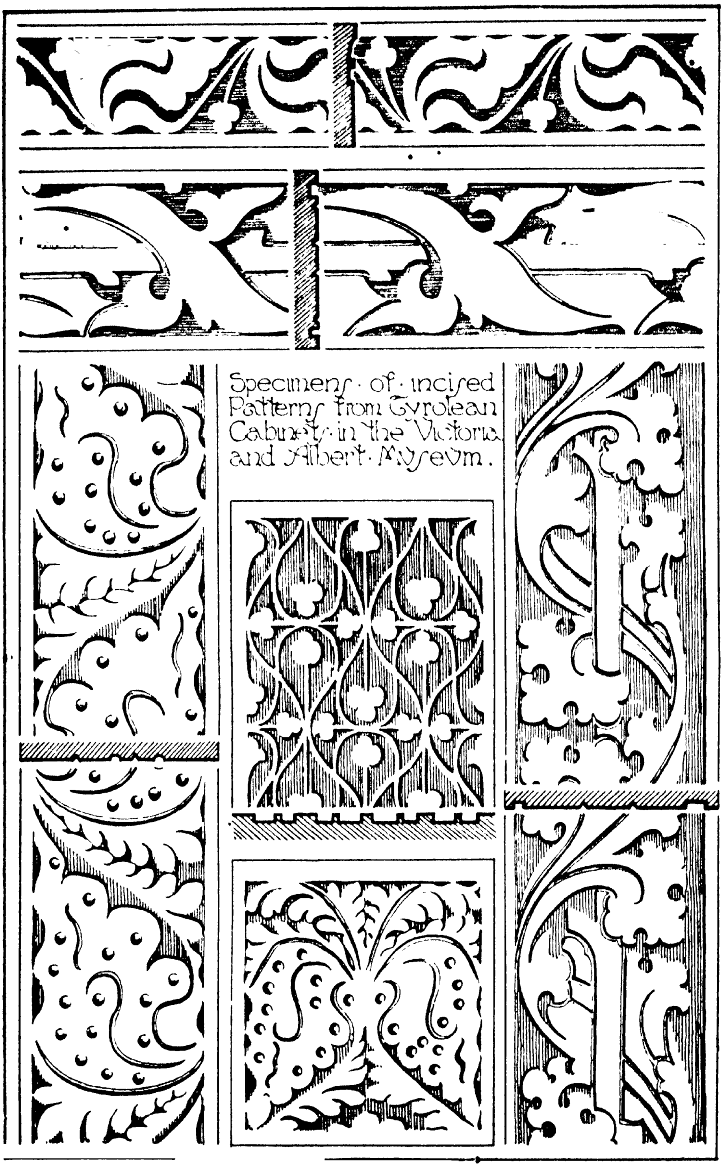

Specimenſ · of · inciſed
Patternſ from Tyrolean
Cabinetſ · in the Victoria
and Albert · Muſeum .

Fig. 9.

geometrical designs and outlines based upon natural motives as on p. 144 ca very well be introduced, and if the recessed part is painted in oil colour ric effects are produced. Decorated in this way is the fine Scandinavian chair show opposite, exhibited at the last Paris Exhibition. It is a rich example of work following the traditional lines of Scandinavian ornament, and provides much usefu detail for lessons, introducing simple carving and recessing. In executing thi work, a good plan is to transfer the design on to the groundwork and then to cu or outline the design with gouges, not necessarily removing all traces of th tooling, for a texture is thus imparted to the background which has a very pleasing effect when coloured. The background can be painted with an admixtur of painter's gold size and dry artist's colour which dries quickly. The surface c relief part of the decoration can be treated with another colour, or simply cleane up and waxed. Mediaeval German artists produced some very beautiful specimen of this work, imitating a "gesso" effect, and gilding the background with fine gol leaf; the raised portions were also gilded and burnished bright to effect a contras of tone. The writer has also seen specimens with a painted background of a re colour with the relief part gilded.

The drawings on p. 39 illustrate simple designs for recessed work whic lend themselves also to decorative colour treatment.

PUNCH WORK is a simple process eminently suited to handcraft wor The designing is easy, and has advantages in the development of taste an observation of proportion by the disposition of units in a much greater rang than the degree of executive skill demanded. Good designs can be effecte with such a simple tool as the leather washer punch, obtainable at ironmonger This is used for circular holes, whilst square and diamond shapes can be cu with chisels. Borders are especially effective when decorated in this way, an panels for doors and constructional models can be decorated with advantage.

Fig. 10 shows three designs for borders. The circular punch should be hel in a vertical position, and struck smartly wit a hammer, cutting the wood about $\frac{1}{16}$ in. deep A slight movement of the tool usually suffice to separate the core, and the next spot can the be proceeded with. The punch has an elongated conical attachment which causes the loos circular pieces to become loose when severa cuts are made. They may then be easily removed by reversing the punch. Square an diamond shaped holes are made with four chis cuts, removing the core with a small chise Composition can be used to fill in the spaces, or they may be painted in contras ing colours. The play of light and shade also has a pleasing effect in this type work.

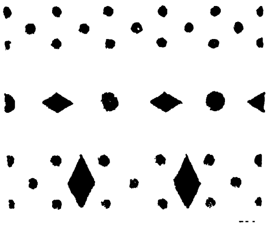
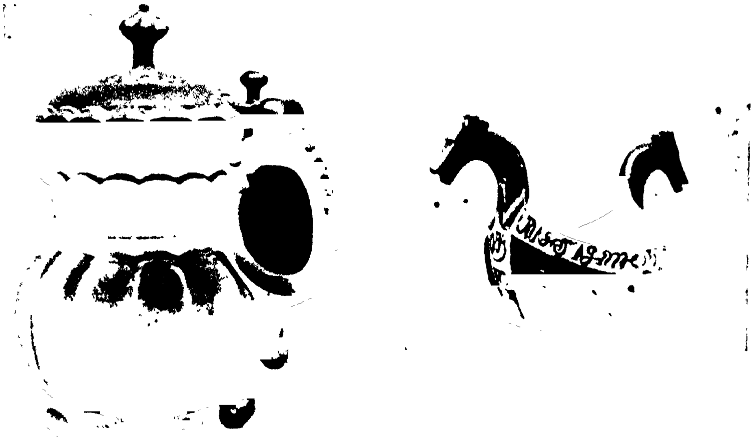


FIG. 10.—Simple patterns for punched work.

Carving, like its sister art inlaying, is also of very ancient origin, as is ev denced by the examples illustrated in the chapter on decorative examples



Norwegian bowls, examples of peasant art, carved wood, the bowl being painted.

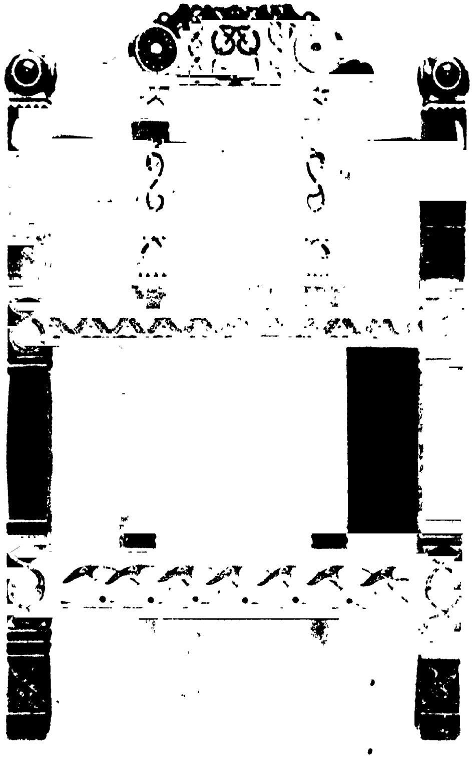


Fig. 10a.—A modern Scandinavian chair shown at the Paris Exhibition.

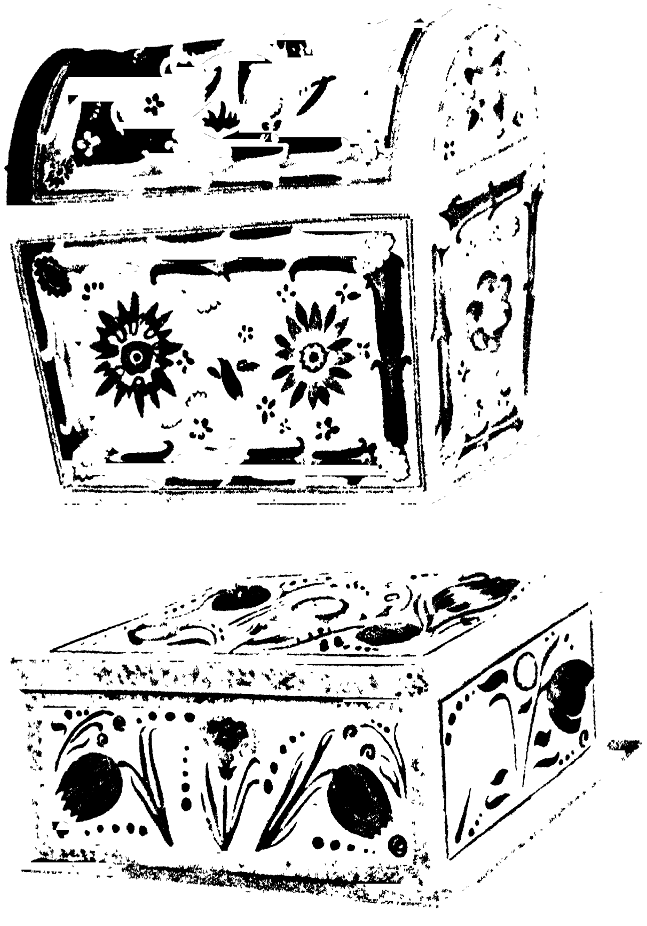


FIG. 11.—Peasant art. Swiss painted boxes from Argovie and Thurgovie. From a watercolour.

handcraft. Nearly all nations have had a period in their history when carving was the pre-eminent craft. Not only has wood been chosen for carved decoration, but metal, stone, and marble, gems, ivory, and pearls, have from the earliest times all been utilized in the practice of this art. Mediæval France and Italy produced most elaborate specimens of carving, especially during the Gothic and Renaissance periods. These masterpieces are unsurpassed from the point of view of technique, with the exception perhaps of work belonging to the Grinling Gibbons school in England. Educationally, they should be regarded as the peculiar products of a period, interesting as studies, but devoid of true æsthetic feeling.

FIG. 12.—A fine carved panel in oak, a simple and effective design, English, early sixteenth century.

VENEERING.—As a form of decoration veneering is a valuable process. It can be employed with advantage in nearly all kinds of furniture and advanced models, and affords good opportunities for the exercise of good design and colour ideas. The diagrams in Fig. 13 show right designs for veneering suitable for door panels, and these with slight alterations of size and arrangement would be suitable for bureau flaps, table tops, and flush doors.

To execute the second example shown on p. 152, the following procedure would be adopted: first damp and stretch a sheet of cartridge paper upon a drawing board and then carefully set out the pattern with pencil lines. Next select suitably coloured veneers—or veneers with contrasting figures—such as fiddle back and mottled mahogany, or American and well-figured Italian walnut, or rosewood and brown oak, then cut the pieces rather larger than the drawing, afterwards planing them to shape with an iron shoulder plane upon a shooting board. It will be found the best plan to lay on a piece of cross banding first; this may be laid in one or two pieces neatly joined with the mitres correctly fitted, and secured by glueing down to the paper, then the three top pieces would be planed and glued down to the paper, these being followed by the diamond and half-diamond shapes. The three large centre pieces would be dealt with next, and so on until the whole of the centre part was completed, after which the cross bandings would be fitted to complete the panel. In the first and third examples diamond shapes are fitted into a large diamond. This type of veneering may be expeditiously executed by glueing up strips of veneers—ebony and satinwood, for instance—with the grain and width coinciding with the required pattern. One end can then be cut and fitted to the diamond shape and consecutive rows gauged off and moved along one diamond in order to effect the change. The fifth example shows inlay-

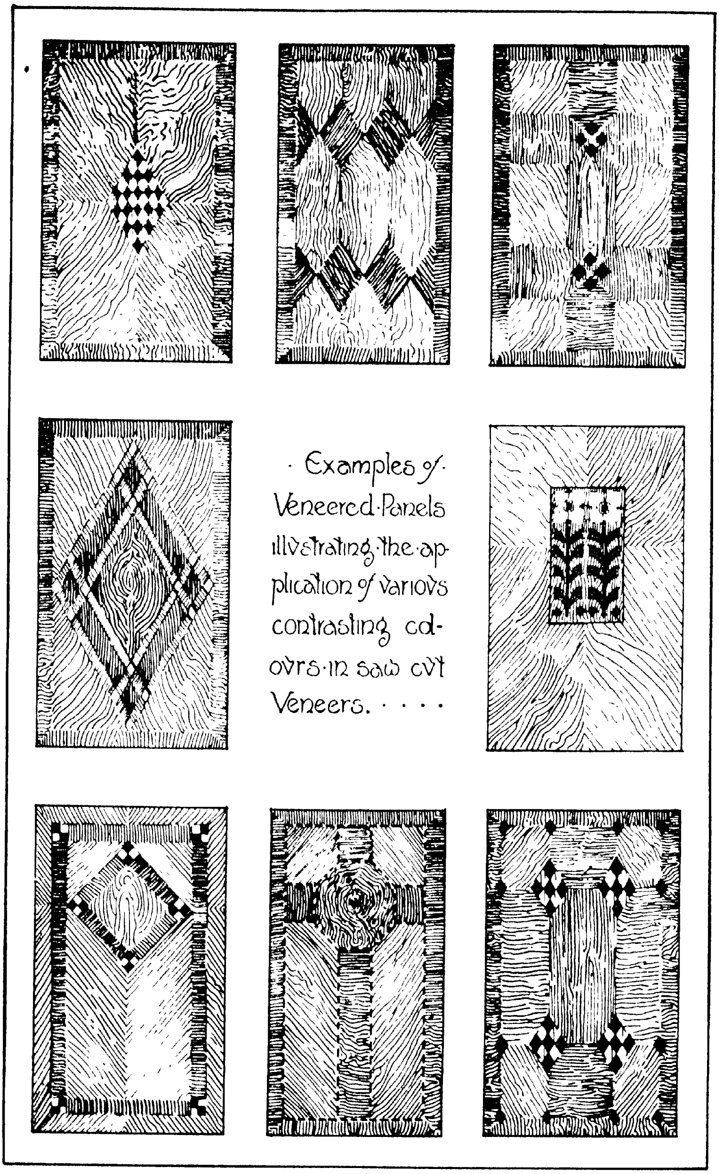

· Examples of ·
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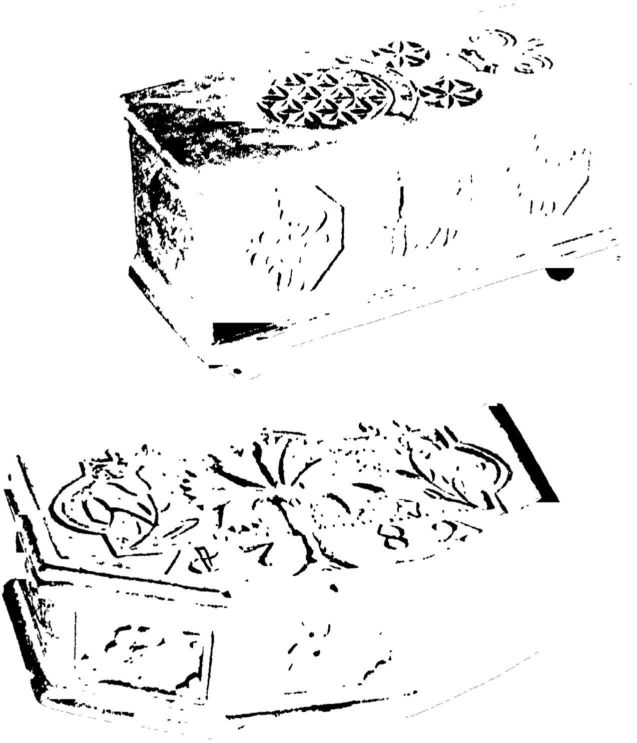
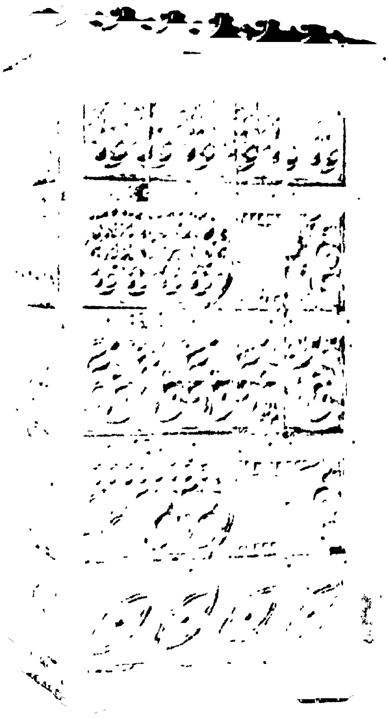
Fig 13.



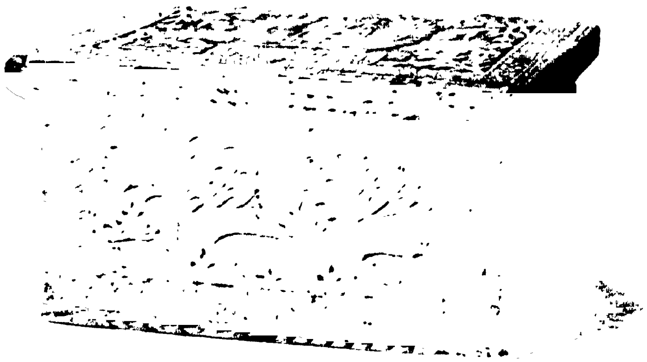
Carved caskets from Lotschental, Switzerland (top, made in 1910; lower, dated 1782)

Carved box from Bohuslan, Sweden.

FIG. 13A



Carved cupboard from Dalarne, Sweden



Carved box from Smaland, Sweden

Fig. 138

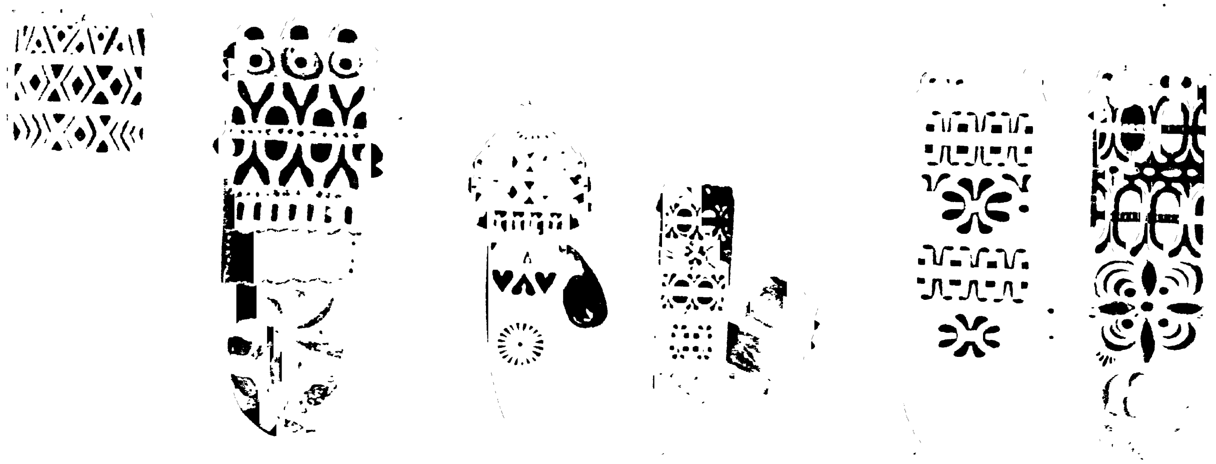


Fig. 13c.—Carved and painted spinning implements from Dalarne, Sweden.

ing; in this case the groundwork would be fitted and glued to paper as described, the inlaying being completed when the groundwork had been veneered; the process of inlaying would then be similar to that described for solid work earlier in the chapter.

Caul veneering is best for work of this kind, distinct from hammer veneering, suitable only for light knife-cut veneers. A caul should be made from ¾ in. pine, rather larger than the surface to be veneered.

The groundwork is well toothed and sized, and when quite dry it is covered with glue, this being allowed to chill before placing the veneer in position with the paper uppermost. The veneer should be secured with one or two veneer pins driven in close to the edge, and then a piece of paper is laid over the paper on the back of the veneer in order to prevent the spare glue sticking to the caul. The latter should be thoroughly heated and then placed over the veneer and firmly handscrewed all together, this causes the glue to run and the pressure applied forces all the spare glue out The work should remain in the handscrews at least twenty-four hours When quite dry the pressure is removed and the top paper removed by toothing, or damping down and scraping with a chisel.

Veneering, consisting of hammer and caul veneering, cannot be fully dealt with in a work of this size, and readers are referred to Wells and Hooper's "Modern Cabinet Work" for further details of this process.

DECORATIVE PROCESSES IN METALWORK.

Appliqué or Applied Ornament.—Rosettes, wreaths, medallions, and enamels are often applied to plain surfaces, and all except the enamels could be fixed by brazing, silver soldering, soft soldering, or riveting, the rivets being shown as part of the decoration as illustrated in Ch. vi, Fig. 7 (3) or hidden (secret riveting) Some old Gothic ironwork has been done by piercing the ornament out of thick metal and riveting it on to a plain background, which gives a very fine effect. In some Spanish work of this kind the effect was heightened by laying on the background a piece of red leather or velvet and then fixing on the pierced work. Doors were decorated in this manner and must have looked very rich and beautiful

Where a number of the same small ornaments are to be applied, they may either be cast from a pattern, or stamped with a die. If the design is cut in a piece of iron or steel the reverse shape to that which is required, really making an intaglio, soft metal is easily hammered into the die so formed without the aid of a press.

Another method is to lay a piece of very thin metal on the die, then on this a piece of lead and hammer both into the die, then take out and trim off superfluous metal. In this way quite nice clean ornaments can be made. This is a very ancient method of making small ornaments, borderings, pearlings, etc. When making the die the progress can be seen by wetting the die slightly and squeezing modelling wax into the sunk portion, the wax impression when removed giving the object in relief. Ornaments can also be fixed by screws, but there is always the liability of their working loose. When the appliqué is of china, glass, or enamel, a setting has to be made and fixed to the background, the enamel inserted and the edges of the setting pressed or burnished down on to the enamel; sometimes a loose setting can be made which, holding the object independently, can then be screwed or riveted to the base, so avoiding the burnishing down of the edges of the setting on to the pearl, stone, or enamel.

Bidri Ware.—There is another form of inlaid work which is called Bidri ware, as it was made at Bidar, a city north-west of Hyderabad

The articles are cast in pewter and the designs are chiselled out and silver hammered in. It is blackened by the application of a solution of salammoniac, saltpetre, salt, and copper sulphate. The design is then rubbed up and the ornament is left in white on a black background. Niello is black on a white background.

Bronzing or **Metal Colouring** is an art which produces very beautiful results on metallic objects, and to obtain an insight of what is possible in this direction the work that has been executed by the Japanese should be well studied. They are certainly unrivalled in this branch of metalwork. The chemical colouring or bronzing of metals requires a knowledge of metallurgy and chemistry, and to produce beautiful results the possession of artistic taste on the part of the operator. The colouring of the object is affected by the purity or otherwise of the metal, the temperature of the solution used, as well as by the purity or impurity of the chemicals used in making up the bath.

The most important point in connexion with the bronzing of metals is that they must be scrupulously clean and of a uniform colour and smoothness before being immersed in the bronzing solution.

Any article made of brass, bronze, gunmetal, or similar alloy may be brought to many shades of brown by the following method: Thoroughly clean the object by boiling in a strong caustic potash solution and well rinsing in three waters; then dip in a solution of nitric acid 2 parts, sulphuric acid 1 part, hydrochloric acid ½ pint to each gallon of dip. Again rinse well in three waters. If the object does not come up a bright uniform colour, well scrub with silver sand and water and repeat the acid dip. When a nice bright colour, dip in a solution of a quarter of an ounce of potassium sulphide to one gallon of boiling water, if it does not come right the first time scour with silver sand and water, and repeat the dip in the sulphide solution; to produce a very dark shade wipe over with a piece of rag that has been dipped in a weak solution of the acid dip; swill well in two or three waters and dry out in hot sawdust. To produce a blue colour as well as a variety of shades of brown, clean, scour, and dip, as described above, and dip in a boiling solution of hyposulphite of soda 4 oz., acetate of lead 2 oz., water 1 gal. Dissolve these separately and add the lead solution to the hypo solution. To produce a steel colour, clean, scour, and dip as before, and immerse in a solution made as follows: Arsenic 8 oz., blue copperas 2 oz., carbonate of iron 2 oz., verdigris 2 oz., spirits of salts 7 lb., then scour well with sand and water and repeat and dry out in hot sawdust. If the colour is too light, blacklead as you would a stove This can now be turned a dark green if required by lacquering with green lacquer. All these bronzes when finished should be brushed over with beeswax or lacquered.

To redden brass articles to match copper, clean, scour, and dip as before, wrap up the article well in thin iron wire and immerse for a short time in the old acid dip. That is, the acid dip that has become too weak to give the bright colour owing to use, but is still used for pickling

Note.—The potassium sulphide should be in dark greenish-yellow lumps and be kept in an airtight bottle

Chasing and carving usually go together, as ornamental work that is made in the solid is usually, if made in iron, forged as near as possible to the shape required, then chiselled out and finally smoothed up with punches and bent files called rifflers. Figures that have been cast are finished off by the latter process. Men who do this kind of work are called "Chasers," but they can usually do embossing as well as modelling (this class of work is really modelling in metal). Examples of this kind which would be modelled, cast, and then chased are illustrated in Ch. IX, Figs. 9, 10, 13A.

Damascening is the term usually applied to metalwork that has been inlaid with gold or silver, and is of Oriental origin, and was established at Damascus during the reign of the Emperor Domitian, first century A.D. The word is also applied to work which is made of a peculiar kind of steel of a watered or striated appearance. This appearance is obtained by welding together a piece of iron and steel. By repeated twisting, doubling over, and welding together a pattern is obtained which is brought out by the application of sulphuric acid and water

Another method of damascening which is not such a good one as that indicated above, but was largely practised in later times, is to cross-hatch the whole of the design to be inlaid with a graver which leaves a number of sharp points. Gold leaf is then applied in successive layers and burnished down on to the points, which keys the metal to the ground.

Fine wire can also be applied in the same manner, working out the design as you go along, tapping the wire down with a light hammer which keys it into position. But this is really a form of onlaying, not inlaying. Another method which gives the effect of damascened work is stencilling the spaces of the design with a compound which is not affected by acids and electroplating the object with gold or silver.

Electroplating, or the electro deposition of metals, is coating one metal with another by means of the electric current, and the process is roughly as follows: The article to be electroplated is first thoroughly cleansed by washing in a hot solution of caustic soda and then suspended on a copper wire which is fastened to a copper rod, resting on the edges of a tank containing a solution of the metal to be deposited. There is a similar rod or set of rods at the other end of the tank which holds suspended in the solution a series of plates or anodes, as they are called, of the metal to be deposited. The path the electricity takes is through the rods and pieces of metal called the anodes, then through the solution to the articles to be plated which are called the cathodes, and through the articles back to the dynamo or battery, when the process is finished or enough metal has been deposited on the articles, they are taken from the solution, washed, scratch brushed, and finished. The thickness or amount of the metal deposited is measured by weighing the article before and after plating, or by the time it is in the bath. The metals mostly used for electro deposition are gold, silver, copper, nickel, cobalt, brass, and zinc.

Embossed Work.—Punch decoration or repoussé work is that kind of work on which designs are raised from the back by means of punches and hammers of many shapes and sizes. The work is usually on thin metal, and is either laid loosely or fixed on a bed of some substance which allows the metal to give, e.g. soft wood, pitch, plasticine, wax, block of lead, a bag of sand or plaster. The design is drawn on the metal and then scribed in so that as the work proceeds the outline remains visible. When high relief is desired it is better to raise the high parts with a hammer, laying the metal loosely on a sand bag; when the necessary amount of relief is obtained the work should be stuck on a bed of pitch, and worked up with punches. A good example of hammered and repoussé work is the silver jug illustrated in Ch. viii, Fig. 5 (1). This is from the Victoria and Albert Museum; other examples of this kind of work are also shown in Fig. 5.

Enamelling.—This is the name given to vitrified substances applied chiefly to the surfaces of metals. It is executed in various ways and styles, and is known as *Plain enamelling*, which is simply the application of opaque or translucent colour in the form of a pattern, etc

In *Champlevé enamelling* the design is cut out of the solid metal, leaving thin walls of metal to outline the design, and the cells thus formed are filled with the various coloured enamels.

In *Basse taille enamelling* the same process is gone through as in champlevé enamelling, but in addition the bottoms of the cells or divisions are modelled in relief, so giving greater depth and play of light to the enamel the cells are filled with.

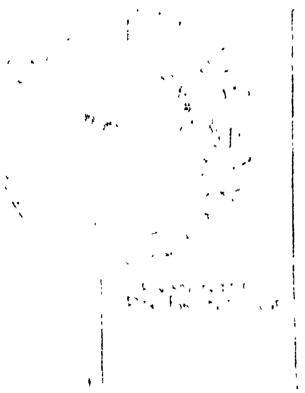
In *Cloisonné enamelling* the design is laid out by means of applying to a smooth groundwork a piece or pieces of rectangular or triangular wire forming or outlining the design, which are silver soldered down on to the groundwork and then the hollows are filled with enamel, in some instances the cloisons are held in position by the enamel only. This is really a modification, or an easier method, of obtaining a result similar to champlevé enamelling.

Plique à jour enamelling is enamelling or enamelled work that can be seen through, simply a network comprising the design and the spaces filled in with various coloured enamels which are translucent. When the spaces in the design are small the object can be fired without a support to hold the enamel in its place, but where this is not possible the object has to be laid on a back or support made of some material such as platinum that will not stick or fuse at the temperature at which the enamel melts. Enamelled work can be done on gold, silver copper, and gilding metal, but the best results are obtained on gold or silver, though often the colours have to be toned down to prevent them looking harsh and raw. When enamelling on other metals which are not so brilliant, paillons are often used to lighten up the design: these are simply pieces of gold or silver foil laid on the enamel, fired, and then covered with more enamel. By this means a reflected light is obtained which can be toned down to suit the design. Enamel in the sense in which it is used here means coloured glass that is fused on the metal, and there is nothing to compare with it for brilliant and beautiful effects. It is one of the decorative arts seen at its best in association with metal work. Hinges, handles, bell pushes, switch covers, finger plates, brackets, fenders, jardinières, grilles, altar rails, candlesticks, etc., could all be made most decorative by the right use of good enamelled work.

To obtain the best results an enamelling furnace must be used, that is a furnace constructed specially for this purpose and heated either by gas or benzolene according to the system that is desired.

The enamel which is supplied in the lump or ground to a certain fineness as required must be thoroughly washed (this is one of the most important processes) and the metal base, which must also be scrupulously clean (scraped for preference), is slightly domed, and the enamel in form of a powder which has been wetted with some thin gum tragacanth if necessary, to make it adhere to the metal, is applied to the back and front of the work with a spatula and well pressed down to form a firm and even coating. This is thoroughly dried and then placed in the muffle of the furnace when the furnace is at the right heat, and baked until the enamel has fused. It is then taken out and left to cool. This process is repeated until the operator is satisfied.

Engraved and Punched Decoration.—Decorative processes in metalwork date back to very remote times, and the early tools and objects in metal in our museums show how decorative effects can be produced by very simple means. The early forms of decoration consisted of series of lines arranged to form a definite pattern, often of a geometric character. Dots of various sizes punched either from the front or back were often arranged in the same manner, roughly shaped bumps were hammered up from the back in thin metal and then these shaped bumps were outlined on the front with engraved lines which gave the form required. The bronze-plated doors of Shalmaneser II, now in the British Museum, and made about 859-824 B.C., are decorated in this manner. A very early example of decoration by means of engraved lines is the bronze pin shown in Fig. 14, p 158, and the bronze shield Fig 14 on the same page shows also an early specimen decorated by *bosses*. The silver plate or dish in Fig. 5, Ch. VIII, from the Victoria and Albert Museum, of a much later date, shows alternate decoration by a similar process, and the wider range of sizes makes it most effective. The gold petrel illustrated in Fig. 14, now in the gold room of the British Museum, is another example of the possibilities of decoration by means of different-sized punches of various shapes, and the finger plates shown in Ch. VII, Fig. 4, show how an arrangement of bosses and engraved lines can be made effective and suitable for modern requirements. Further applications of these simple processes are illustrated in Ch. VII, Fig. 5.



Engraving is cutting a design with a graver or burin, but it can be done with other tools which produce a similar effect. In some kinds of engraving the tool is fixed into a handle of wood and used by hand, but in other kinds of work it is used like a chisel and hit with a hammer. In memorial tablets the design is cut by the latter method, and different-shaped chisels are used, depending on the design and shape of the cutting. In some instances coloured wax is laid in the grooves or channels so formed. The greater part of old work, however, was cut with chisels or gravers leaving vee section lines of various widths. Some modern work is done with a machine called a *Router*, which cuts away the groundwork leaving the letters or ornament in relief.

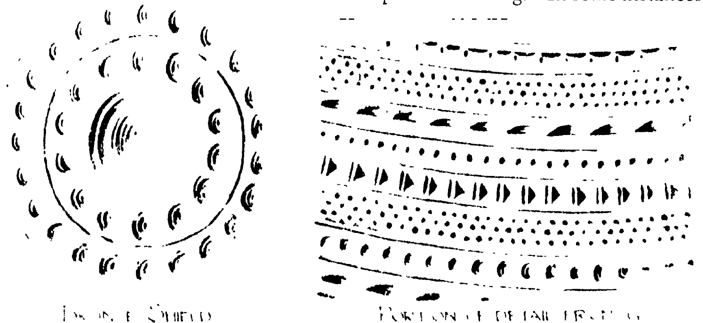


Fig. 14.—Ancient metalwork in the British Museum.

Filigree.—This consists mainly of round wires, soldered together in various patterns, sometimes, with little metal balls and little leaves soldered to the ends of the wires, producing a most charming effect. Variations of this is where two pieces of wire are twisted together forming a kind of rope, using this instead of the single wire, and also where the filigree work is fastened to a background.

Gilding is not always applied to metalwork by electro deposition, as gates, railings, signs, weather vanes, etc., are ornamented by applying gold size, and when this becomes tacky gold leaf is laid on. This is very durable when properly done and good quality gold used. It is also done in a cheaper way by using gold powder or imitation gold leaf, but this has to be varnished with a transparent varnish to last, and when this is affected by the weather the alloy underneath turns black. The same method is used for applying copper, silver, and bronze powders of various colours and is known as bronzing, but it is only a sham bronzing

Another method of gilding, called fire gilding or mercurial gilding, is to cover the article with an amalgam of gold and then heat to volatilize the mercury; afterwards dip and scratch brush or polish as required. This is the most durable method of gilding, but it is also the most expensive.

Inlaying.—This very ancient and historic method of ornamenting metal produced some remarkable examples of craftsmanship, and the many pieces of work shown in the British Museum of Saracenic and Persian origin should be well studied, so that an idea of the possibilities of this kind of work may be obtained. Metal can be inlaid with metal, or with coloured wax, or with coloured stones or gems, or with enamel. Damascening, niello, and Bidri work are forms of inlaying. As for example the Celtic finger plate Ch. VII, Fig. 5 (10), instead of being raised as shown, could have the same design worked out with two parallel strips or threads of copper. When inlaying wire only a groove need be cut with chisel shaped and held as shown in Fig. 15. The wire is annealed and placed in the groove; then the edges of the groove are hammered down on to the wire, the work is planished up from the back and the face finished off as required. The Tudor plate on p. 78, instead of having the rose embossed could have a plate of copper inlaid to the outside shape, and the other lines giving the form could be engraved on the copper plate after it was inlaid The stars in the memorial tablet illustrated in Ch. XII are of silver inlaid, and show up well against the rich coloured copper.

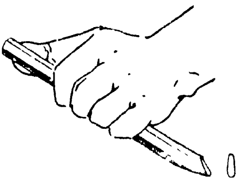


FIG. 15.—Method of holding an engraving chisel.

When wax is to be inlaid the design is cut away, leaving a wall of metal all round, and the wax, which should be of brittle character, is powdered fine and the cells filled with it, then the object is warmed so that the wax melts and fills in the design. This operation is repeated until the cells are filled; the plate is then cleaned up with pumice stone, or Water-of-Ayr stone, and polished. The memorial tablet shown in Ch. XII has been done in this manner. Fusible metal could also be used in the same manner.

Lacquering.—Though this is a method of decorating metals it really comes under the finishing or preserving of metal surfaces. See chapter on "Finishing Metal Objects," p. 177.

Metal Spinning.—This process deals with the working up of thin sheet metal on a lathe, and only applies to what is known as hollow ware. It is a cheaper and quicker method of making such things as reflectors, tea and coffee pots, bowls, cups, bases for candlesticks and lamps, etc. It consists of turning a wood or metal chuck to the shape required, and then fixing between the chuck and back-centre of the lathe a flat circular piece of metal. The lathe is then put in motion, and with a steel burnisher, which is in a long handle and held in the hand and under the arm of the operator, the metal is burnished down on to the chuck. To prevent wrinkles being formed in the metal while it is being spun or burnished down on to the chuck, a flat piece of steel is held up against the back of the metal by the left hand of the worker. In spinning deep articles the metal has to be frequently annealed. Spinning requires a great deal of skill and knowledge of materials to avoid making "wasters," as they are called. Spun work is often further decorated by etching, that is, a design is drawn or stencilled on the spinning and the spaces are eaten away with acid; this is known as etched work. Stamping has to a certain extent supplanted spinning, but sometimes the work is partially stamped and then finished by spinning.

Niello is the name given to those articles of gold and silver which have the design engraved, and the engraved lines filled with a black composition composed of silver, copper, lead, and sulphur, which is made up separately and powdered very fine. This powder is applied to the metal with borax which acts as a flux; the article is then heated, the compound liquefies and runs into the hollows of the design. When cool the work is scraped over, polished or burnished, leaving the design in black upon the metal. This method is said to be the origin of engraving (printing), as when testing the work for accuracy, etc., the lines were filled with a black substance and a piece of paper was pressed on to the surface which caused the reversed design to be transferred to the paper and any faults could be easily seen. Tommaso Finiguerra was the inventor, and he lived in Florence about the middle of the fifteenth century. He was skilled in niello work.

Piercing.—This is accomplished in many ways according to the material and its thickness. Thin material can be punched or pierced by means of cutting dies, or pierced by cutting out the design with a hand fret saw, or a power fret-cutting machine. Another method is to use various shaped chisels and afterwards trim up with a file.

The examples shown in Ch. VIII, Fig. 6, would be best cut out with a fret saw; if a number were required a pattern could be made in mahogany and castings made from it.

Solder Decoration.—Another method of decorating metal surfaces is to stencil out a pattern on the object, fill the spaces with a black varnish, or some composition that is not affected by the flux and heat, scrape clean the pattern that is left by the stencil, and apply the flux and ordinary soft solder with a soldering iron, then wash the varnish off and the design in solder will be left in relief.

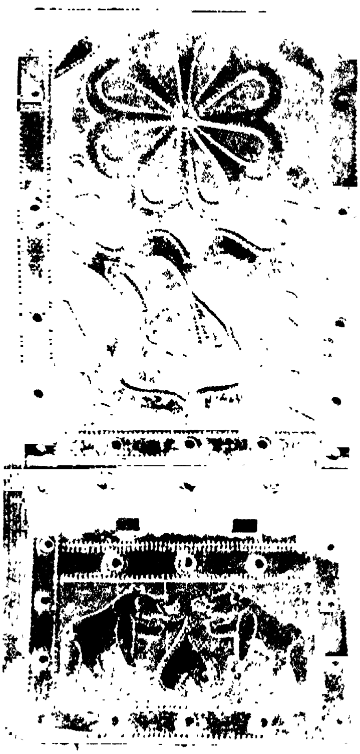
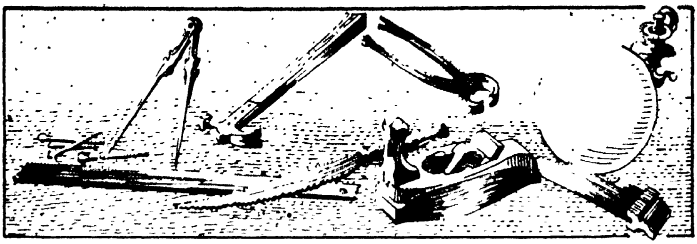


FIG. 16.—Wooden Cow Collar with metal appliqué from Appenzell, Switzerland.



Tools of the early sixteenth century from the picture "Melancholia" by A. Durer.

CHAPTER XIV

TOOLS: THEIR EARLY FORMS & HISTORICAL DEVELOPMENT

"Without tools man is nothing, with tools he is all."—CARLYLE.

"The smith came holding in his hands the tools—the instruments of his craft, anvil and hammer and well-made pincers, wherewith he wrought the gold."—"Odyssey," Book III.

INTRODUCTORY.

THE study of the development of tools is one, which, owing to the absence of records referring to their early uses, is necessarily difficult, and direct evolution hard to prove. Study of this subject shows that development of races and of tools may be presumed to have proceeded along very similar lines in different countries at different times. But it should be clearly understood that the definite uses of tools and implements belonging to prehistoric times is largely pure conjecture. To correctly trace *evolution* in tools is an impossible task regarding prehistoric examples, and the study of tools belonging to a particular country is necessarily largely conjecture in its early stages. It is, however, interesting to note that the "development" of tools and implements, through which may be traced the development of man, has, as indicated above, proceeded in very like ways in countries so far apart as England and Egypt. European developments, in England, Sweden, and Switzerland for instance, exhibit some remarkable sequences of development in design and material. For the purpose of object lessons to handcraft classes the national aspects of the subject are probably sufficient, thus considerably reducing the range of the subject. It is recommended that for purposes of demonstration, wherever possible, large charcoal drawings be made from the actual examples, the drawings being made permanent by the application of some fixing solution and placed on rollers.

The Saw.—The first tool to be dealt with is the saw. Its antiquity is indicated by many classical references, and there are references in Isaiah to saws and planes. Illustrations of various saws from earliest times are shown in Fig. 1, but it should be clearly understood that these are shown as

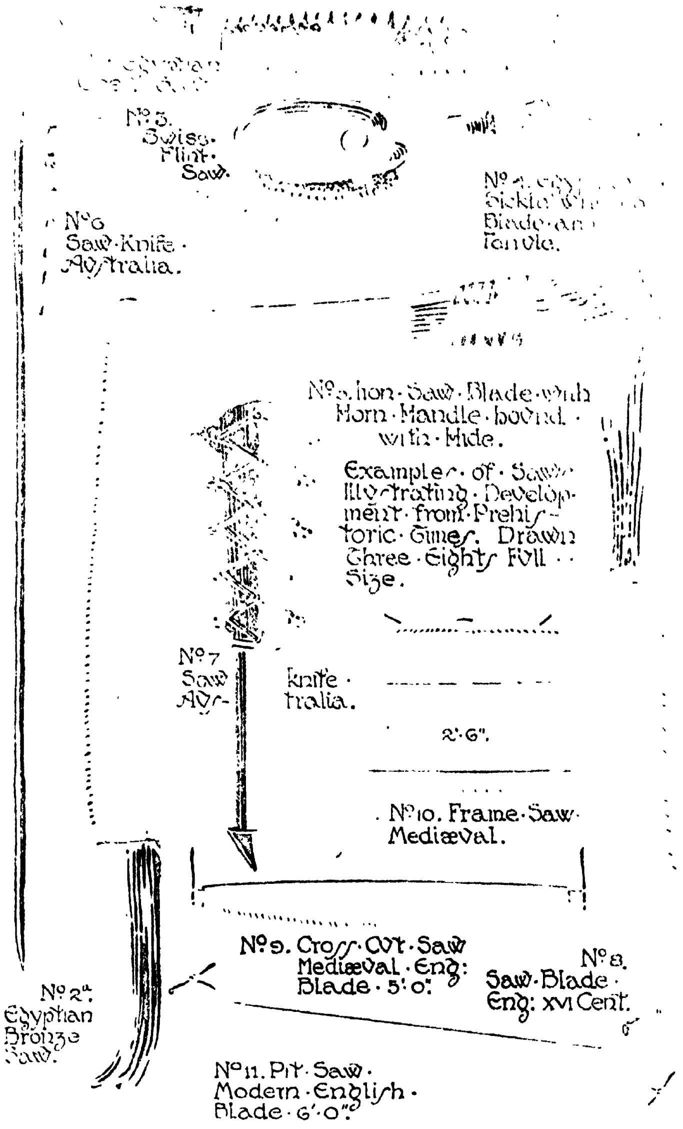
Nº 3. Swiss Flint Saw.
Nº 4. Egy... Sickle with ... Blade and Handle.
Nº 6 Saw Knife Australia.
Nº 5. Iron Saw Blade with Horn Handle bound with Hide.
Examples of Saws illustrating Development from Prehistoric Times. Drawn Three Eights Full Size.
Nº 7 Saw knife Australia.
2'6".
Nº 10. Frame Saw Mediaeval.
Nº 9. Cross Cut Saw Mediaeval Eng: Blade 5' 0".
Nº 8. Saw Blade Eng: XVI Cent.
Nº 2a. Egyptian Bronze Saw.
Nº 11. Pit Saw Modern English Blade 6' 0".

FIG. 1.

interesting examples characteristic of certain periods, rather than an attempt to show definite "evolution".

The example, Fig. I, No. 1, shows a chert saw of Egyptian origin. Chert is a kind of stone, which here has been worked by a curious chipping process so as to produce a serrated edge. The particular uses of this type are not definitely known, but it is presumed to have been chiefly for bone and meat sawing.

No. 2 on the same page is, like the above, in the British Museum It is a harpoon, and was produced in a fashion similar to that employed in the Egyptian chert saw. These belong to the European and Egyptian Stone Ages respectively.

No. 3 illustrates a Swiss saw, after Lubbock, the blade of which resembles the first example, and is fixed into a wooden handle. The reason for the hole is not clear. The use of this tool was probably also for bone and wood used in the early Swiss lake dwellings. The Egyptian iron saw, illustrated in No. 4 on the same page, is a particularly fine example, and appears to have been suggested by a sickle. The blade of this implement is of iron, and it is secured to the handle by insertion, with an iron ferrule for extra security. The comparative absence of timber-producing trees indicates the reason for so many early structures being made of stone, or, as is frequently the case with tombs, hewn from the solid rock. Authorities on ancient Egyptian architecture assert that timber was used to a considerable extent in prehistoric times, producing in support of this theory evidences of stone dwellings of a later period, which have obviously been inspired by earlier wooden dwellings.

No. 2a illustrates another Egyptian saw in the form of a knife with one serrated edge. It cannot be decided which is the earlier of these two types, and their uses can only be surmised.

The illustrations Nos. 6 and 7 show two saw knives of Australian origin. They consist of sharks' and animals' teeth fixed in the first case by embedding in gum. They were used more as knives than saws.

The second example of this type, No. 7, is a particularly interesting specimen, consisting of teeth laced into a wooden handle in a most ingenious fashion.

The tools shown in Nos. 5, 8, 9, 10, 11, are all of English origin. The first of the latter series is, together with No. 8, exhibited in the Guildhall Museum of the City of London.

No. 5 is prehistoric, whilst the example No. 8 was excavated in London Wall, and was probably attached to a handle by the insertion of the tang, and secured by pinning through both handle and tang, as is indicated by the example. A mediæval frame saw is illustrated in No. 10, used chiefly for cross cutting; "deeping," or splitting logs from end to end in planks, etc., was doubtless effected by means of the pit saw, the use of which still remains in country districts. A two-handled cross-cut saw is illustrated in No. 9. These were used also for splitting small logs, the latter being fixed in a vertical position. During the eighteenth century veneers also were cut in this manner, as an examination of authentic old work will show. The illustration No. 11 is of a pit saw, the use of which is now almost entirely superseded by machine saws. It was and still is used to some extent for deep cutting a log from end to end. The log is wedged above a "pit" or well hole, and one sawyer is above the log, the other below. The cut is made on the downward stroke, and it is necessarily a tedious process compared with up-to-date vertical frame sawing, by which twelve or more cuts can be made simultaneously through a log 2 ft. and upwards in diameter.

No account of saws, however brief, would be complete without mention of Japanese saws. These are fashioned as illustrated in Fig. 2, and, as will be seen from the diagram, the teeth are spaced in an opposite direction to those of English saws. They resemble large carving knives, and the cut is made on the backward stroke instead of on the forward one, as is the case with the English pattern. Native Japanese craftsmen are remarkable adepts in the use of these tools, some of which have teeth on both edges, thus combining two grades of cutting edges in one instrument. In the Pitt-Rivers Collection at Oxford are some interesting models of these tools.

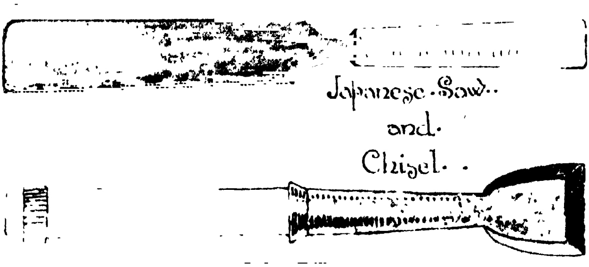

Japanese Saw and Chisel.

FIG. 2.

The Chisel.—The term is derived from the French word "ciseau," the Latin "seco" (I cut) having a similar meaning, and may safely be supposed to have been practically the first tool used by primitive man. It is the forerunner of the plane, and the term includes generally gouges, turning tools, and various metalworking tools. In the British Museum and other collections there are many existing examples of implements belonging to the early Stone Age which were probably used for "chiselling" and like purposes. Of these may be mentioned a "chopping tool" found at Stoke Newington and a primitive "double chisel" found at Les Eyzies, Dordogne, France, both of which are in the British Museum. They are necessarily of a very simple and crude character, being only roughly shaped pieces of pebble. The Neolithic, or later Stone Age, marks a very considerable advance in tool production; methods of hafting were introduced, and the processes of grinding and polishing the stone blades led the way to the adoption of other materials than flint and quartzite, the two latter being the chief materials employed up to this time. Reference to Fig. 3 will show two good examples of Neolithic celts of flint. One resembles a

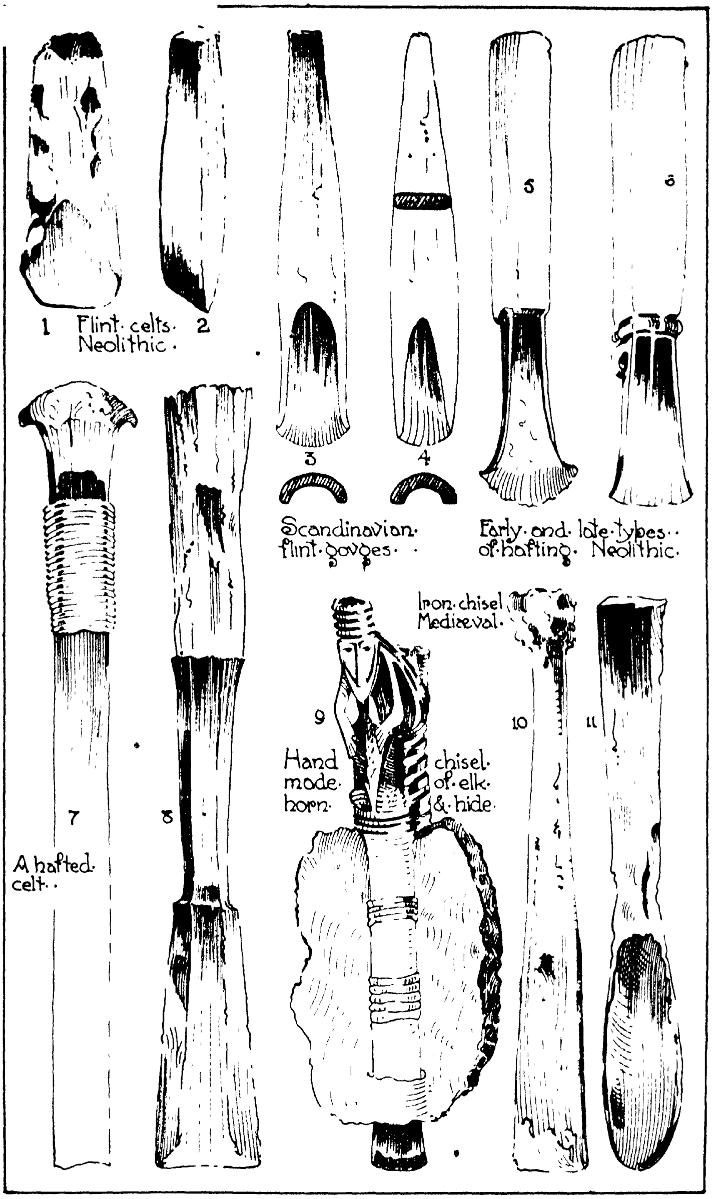

1 Flint· celts· 2
Neolithic·
3
4
5
6
Scandinavian· flint· gouges·
Early· and· late· types· of· hafting· Neolithic·
7
8
A hafted· celt··
Iron· chisel Mediæval·
9
Hand made· horn·
chisel· of· elk· & hide·
10
11

FIG. 3.

"gouge" and the other a "cold chisel". The uses to which implements of this type were put can only be conjectured, but whether used for breaking clods of earth in agricultural operations or as weapons of defence or sustenance, the process involved would be that of "chiselling," the implements being based upon the action of a wedge, which forms the basis of cutting actions in planes and chisels alike. Hafting proceeded differently in various countries, one interesting example in the British Museum—of Swiss origin—showing a small stone axe fixed into horn and then mounted in a wooden haft. The centre part of horn was introduced in order to lessen the risk of the handle splitting. In Fig. 3 is also shown two fine specimens of Scandinavian gouges belonging to the Neolithic period. We now come to a stage, approximately some five thousand to six thousand years ago, which marks the introduction of metal into the manufacture of primitive tools. This period is known as the Bronze Age, and it is remarkable also for the artistic character of its productions as well as the extraordinary moulds used for casting the implements. Authorities agree that the use of bronze, strangely enough, preceded that of iron. Early celts of the Bronze Age are really metal copies of their Neolithic prototypes; they were probably used more as axes than as chisels, as we understand the term. There are many evolutionary stages before the type shown in Fig. 3 (5) was reached, the expansion of the blade towards the cutting edge is accounted for by the hammering out necessary to harden the edge. The hafted celt shown in Fig. 3 (5) is drawn from an example in the British Museum, and the haft is not the original one. Both the types shown in Fig. 3 (5, 6) are known as socketed celts, that is, a socket which receives the handle is made in the butt end of the implement, this being effected by means of core casting. In some cases a loop or ear-piece was provided—as is the case with Fig. 3 (6)—which presumably was bound for greater security. The example shown in Fig. 3 (7) is an earlier one, a cleft stick received the celt, which was more firmly secured by binding with thongs of hide. Socketed celts of various types may be considered as the latest development of the implement in prehistoric times, although there are many spear-heads and swords still existing which indicate the development among implements of war. A big jump is now necessary, the next example shown being a relic of the Roman occupation of Britain, see Fig. 3 (8). This specimen is now in the Pitt-Rivers Collection at Oxford, and curiously enough, it is made on almost identical lines to the implement illustrated in Fig. 3 (5). It is obviously of wrought iron, is octagonal in section through the iron socketed part, tapering away to a hexagonal shape at the cutting edge. This was found in 1863 during excavation at the corner of Great Winchester Street, London Wall. There is also a fine example, similar in general character to it, in the Guildhall Museum.

The mediæval iron chisel illustrated in Fig. 3 (10) was found at Wapping, and belongs also to the Romano-British period. It was probably used for stone dressing, as may also have been the curious spoon-like gouge illustrated in Fig.

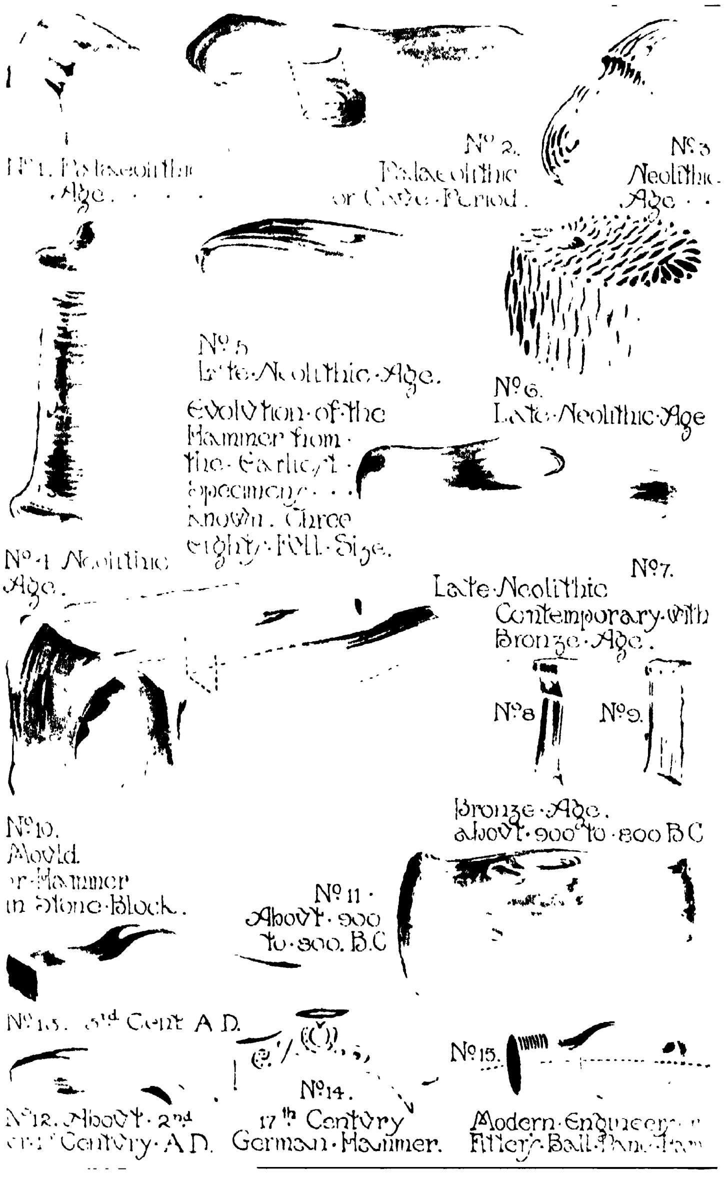

No. 1. Palaeolithic Age.
No. 2. Palaeolithic or Cave Period.
No. 3 Neolithic Age.
No. 4 Neolithic Age.
No. 5 Late Neolithic Age.
No. 6. Late Neolithic Age
Evolution of the Hammer from the Earliest Specimens known. Three eighths Full Size.
No. 7. Late Neolithic Contemporary with Bronze Age.
No. 8
No. 9.
Bronze Age. about 900 to 800 B C
No. 10. Mould for Hammer in Stone Block.
No. 11. About 900 to 800. B.C
No. 13. 3rd Cent A.D.
No. 12. About 2nd Century A.D.
No. 14. 17th Century German Hammer.
No. 15. Modern Engineers Fitters Ball Pane Ham

FIG. 4.

3 (11) also belonging to the period last mentioned. In Fig. 3 (9) is illustrated a remarkable chisel, a hand adze, from the Pitt-Rivers Collection. It has a short steel blade fitted into a handle of elk horn elaborately carved. Two pieces of hide are attached to the stem part in order to protect the knuckles when using the chisel. It was used with a chopping action for shaping canoes. An interesting native Japanese chisel illustrated in Fig. 2 is constructed on the socketed principle, and similar in general outline to the example, Fig. 3 (8).

THE EVOLUTION OF THE HAMMER.

In Fig. 4 an attempt has been made to show the gradual development of the ordinary hand hammer from the earliest known types. The illustrations show broadly the various stages it has passed through and the many methods adopted for attaching the head to the shaft or handle. As in all human inventions progress has been made in a series of steps.

The hammer, a tool of percussion, is the most widely used of all tools. The prototype of the hammer is of course found in the clinched fist, a tool or a weapon according to circumstances, and one that man soon learned to use. When he found that this was not hard or powerful enough he would naturally look around for something better, and this he found in rounded pebbles. These were used by primitive man for many purposes, and it is only when the stone was chipped or marked by blows caused through working on a harder material that it can be recognized as having been used as a hammer.

Fig. 4, No. 1, shows a piece of flint that has been used as a hammer. It was held in the hand and is known as a hammer stone. Some hammer stones were oval in form, and others had pits or depressions chipped out of both sides for the thumb and finger to fit into so that a better grasp could be obtained. Fig. 4, No. 2, shows a hammer head of deer horn with a hole for the handle. This is in the British Museum and was found in a British barrow in association with a burnt body at Lambourn Downs, Berkshire. In the Guildhall Museum there are some hammers complete with handles made from the antlers of the red deer. Fig. 4, No. 3, is an oval stone hammer grooved for the purpose of lashing it to a handle. Similar forms were used as net sinkers, as is indicated by names and description in the Pitt-Rivers Collection at Oxford. Fig. 4, No. 4, is from the Horniman Museum, and was held in the hand. This comes from Vancouver in North America. A similar object was used in Tahiti for pounding bread fruit and called a pounder. Fig. 4, No. 5, is a quartzite hammer made from a pebble, and the hole has been made by pecking or drilling a pit on either side until the two depressions met. For drilling the holes the drill was simply a stick twirled between the palms of the hand and fed with sand and water (see Fig. 6). Some of the European specimens were perforated by means of a piece of cane twirled between the hands and fed with sand and water as illustrated in Fig. 6, No. 4. Fig. 4, No. 6, is a decorated hammer head, and was probably not used for serious work. There is in the British Museum a broken portion of a stone hammer decorated with a number of lines arranged to form an all-over pattern, and perforated for the reception of a shaft; this was found in a Mycenæan tomb that dates back to about 1350 B.C. Fig. 4, No. 7, is a stone hammer that was found in the Thames. Fig. 4, Nos. 8 and 9, illustrate hammers of cast bronze hollow at the top end for the insertion of a shaft. That shown in No. 8 was found at Thorndon in Suffolk, and No. 9 comes from Ireland. The round heads shown in No. 9 are simply decorative Fig. 4, No. 10, shows a limestone mould for casting hammer heads. At the bottom of the mould a depression will be noticed. This was for the reception of a core or circular piece of clay or soft stone, so that when the metal was poured into the mould it would flow round this core, and when the metal had solidified and was removed from the mould and the core taken out a hole would be left ready for the shaft. Fig. 4, No. 11, is a cast bronze hammer head about 7 in. long and 3½ in. in diameter and has been much used. Fig. 4, No. 12, is an iron claw hammer practically the same shape as the modern tool. Fig. 4, No 13, is also of iron, and it has a thin pene and a rectangular face. Fig. 4, No 14, is a German claw hammer with a square face and the claws rounded on the top and decorated on the sides with engraved lines and dots. Fig. 4, No. 15, is a modern example of an engineer's or fitter's hammer made of steel with hardened face and pene. In the Guildhall Museum there are two hammer heads of interest, one is an iron war hammer, or as it is called, Martel de fer, of the fifteenth century. It is similar in shape to our present-day double square face planishing hammer, with the exception that the faces have nine projecting spikes about half an inch long, thus making it more of a club. The other is a Roman claw hammer of a peculiar shape and made of iron. This was found at Austin Friars.

How the hammer stone became a hammer head is not known, but nearly all the stone-headed hammers from various countries show very simple methods of hafting, and the smith of to-day holds various tools in the manner that was usual in the early centuries. The illustrations forming Fig 5 show various methods of hafting, so that a larger amount of power can be obtained without hurting the arm or wrist. In Australia the Aborigines fixed the stone head of their hammer to a handle made from the small branch of a tree, with a kind of gum or cement (see Fig. 5, No. 1). Fig. 5, No. 2, shows how the head, which has a groove round the centre, was fastened by means of moistened strips of hide which contracted in the drying, so binding the stone head firmly to the handle. In Fig. 5, No. 3, the head is wrapped round twice with a flexible branch and tied with split rattan. Fig. 5, No. 4, is a stone hammer head with one flat side fitted to a piece of a tree from which a branch has grown out at right angles and the stone head is tied on with sennit cord. The head of Fig. 5, No. 5, is attached to the handle by means of a leather thong. Sometimes the handle and binding is in one piece, as when it is made of substance like whalebone or horn

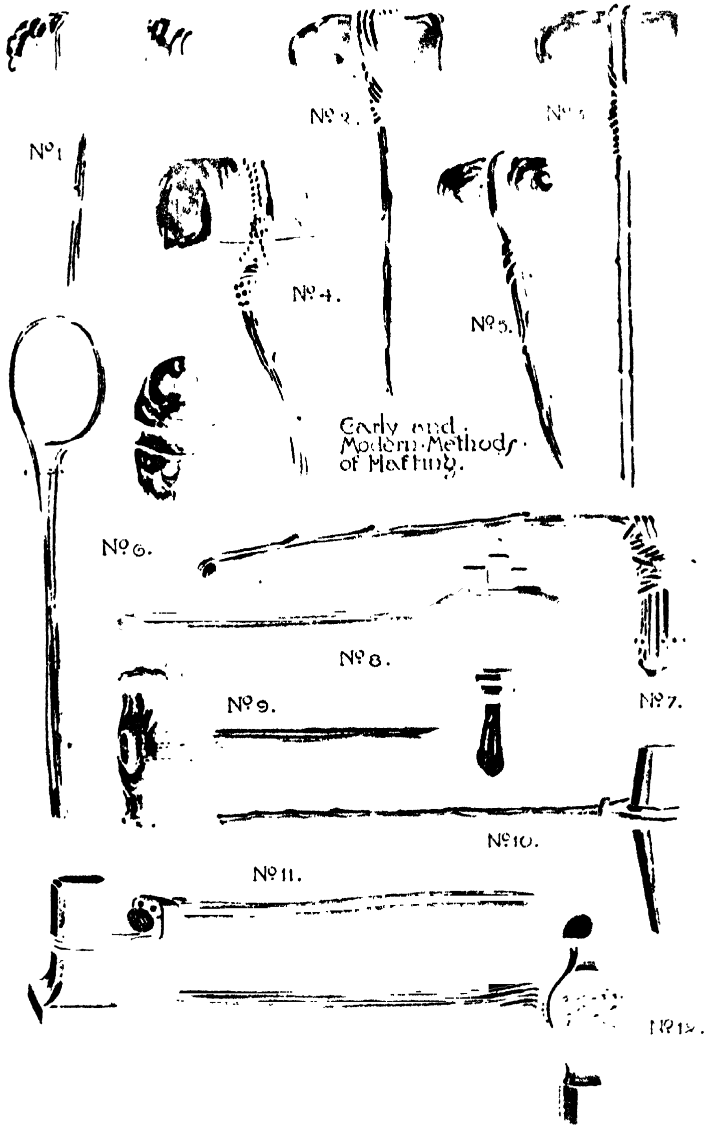


Fig. 5.—The evolution of the hammer.

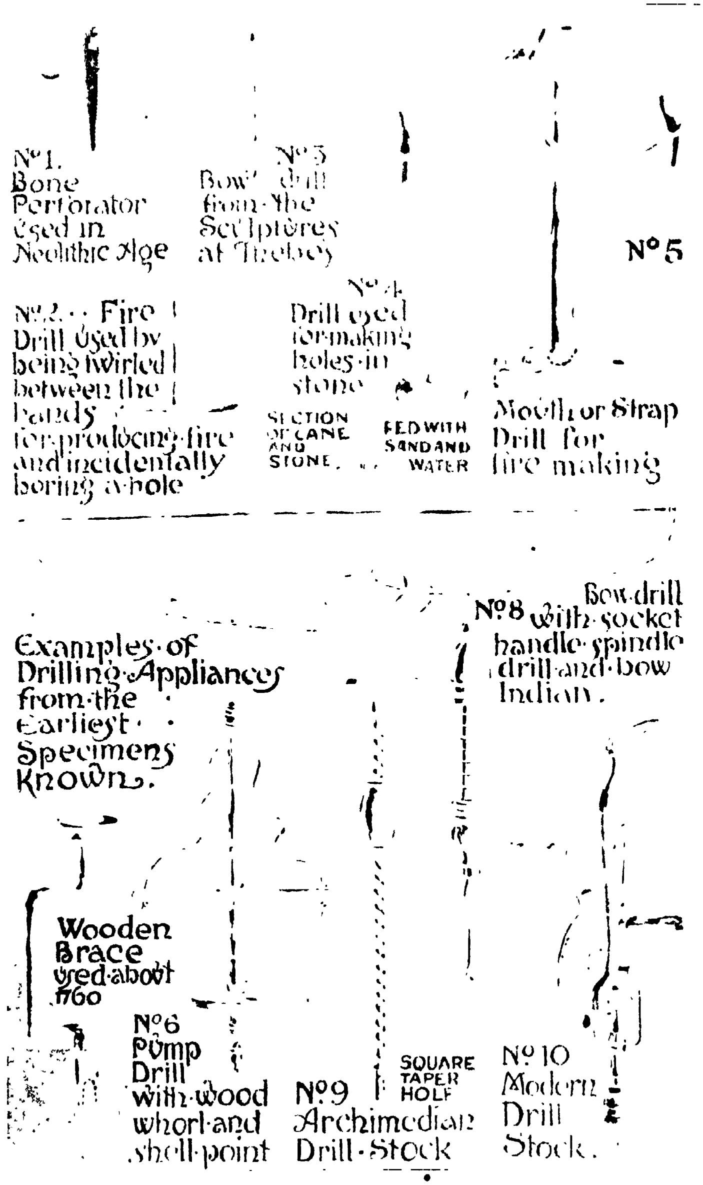
and tied round the head and then round the shaft while in a pliable condition. When it dries, it hardens and is practically irremovable. Fig. 5, No. 6, shows a haft of flexible wood cut away and then bent round the head and pegged down. Fig. 5, No. 7, is a right-angled branch and the end is fitted tightly into the hole left in the bronze hammer head. It is tied on with sinews or strips of hide. These bindings were very often done in quite a decorative manner. In Fig. 5, No. 8, a piece of wood is wedged into the hammer head and this is fitted to a shaped shaft that has a rectangular hole in it. The piece of wood with the hammer head fixed to it was put through the hole and kept in position by a taper wedge. Fig 5, No. 9, has a hole right through the hammer head which is of bronze, and the end of the shaft is split and a simple taper wedge of wood driven in. In Fig. 5, No. 10, a withy, or willow branch, is wound twice round the cold sett and an iron coupling or ring slipped on. Fig. 5, No. 11, shows a modern method of holding a flatter. A piece of $\frac{5}{16}$ in. round iron is made red hot and bent twice round the flatter so that when it cools it holds the tool firmly. Two holes are then drilled close together in a hammer shaft, the ends of the rods are bent at right angles and put through the holes in the shaft, bent over and clinched. A collar from $\frac{3}{4} \times \frac{3}{16}$ in. iron is then made and shrunk on. Fig 5, No. 12, is a modern method of fixing an engineer's hammer to the shaft. The shaft is fitted to the eye and then cut down with a saw parallel with the head. A wedge of iron is made with a number of burrs thrown up on the faces and edges with a diamond-pointed chisel. When the wedge is driven in the burrs catch in the wood and the head does not readily work loose. This kind of hammer is made heavier at the face than at the pene end so that it will naturally assume a position in the hand with the face downward, so relieving the user from the necessity of specially forcing it into that position. In using a hammer it is essential to study the difference between a sharp blow with a light hammer and a slow blow with a heavy one, the former penetrates the farthest and gives least lateral pressure, while the latter penetrates less and spreads more.

Of modern hammers there is a great variety, and a volume could be written on this subject alone, for each particular trade has its own set, and a set comprises any number. There are also the mechanically operated hammers, such as the trip or tilt hammer, the steam hammer, and the pneumatic hammer. When one considers all the hammers, from the tiny ones used by the jeweller to the mighty steam hammer with its hundred-ton blow, we are bound to marvel at man's ingenuity.

Forms of Drilling Appliances.—A tool or appliance for making a hole is a world-wide necessity. So early was the need felt that the drill is of unknown antiquity, but the reproductions on the next page show a few methods and appliances in use in various countries, and at various times. Fig. 6, No. 1, shows a bone perforator in use in the Neolithic ages. This is in the Horniman Museum. All the early needles for sewing were of some sort of bone or horn. Fig. 6, No. 2, is a "Firedrill," and although it does not bore a hole as we understand the term, it could be used to make a hole when other appliances were not available, and was the primitive method of getting fire before the introduction of flint and steel. Fig. 6, No. 3, is a drawing of a bow drill from the sculptures at Thebes, and as this city was at the height of its prosperity in 1600 to 800 B.C., some idea can be gained of the age of a tool for drilling holes. In the Pitt-Rivers Collection at Oxford there is a drawing, taken from a fresco in Egypt, of a man using the same kind of drill, and boring a hole in a chair with it, the worker sitting down on a stool while boring. In the Horniman Museum there is a fire-making bow drill, the bow of which is the rib of a walrus, and the thong of hide. Fig. 6, No. 4, shows the ancient method adopted for boring holes in stone, but it must have been very laborious. In Fig. 4 some hammer heads are shown which have been perforated in this manner. Fig. 6, No. 5, is known as a mouth or strap drill for fire-making and has been used in Alaska, North America. The shaped piece at the top is held between the teeth, and in some instances a piece of bone or stone is inlet to take the point of the rod and so prevent it slipping or firing by the circular motion. The strap is simply a piece of hide tied round pieces of bone that can be held conveniently in the hand. The circular motion is obtained by pulling each end of the strap alternately. Fig. 6, No. 6, is a pump drill of very primitive construction; the centre rod is a piece of cane with a circular piece of wood called a whorl wedged in position. The cross bar is a flat piece of wood with a hole to take the rod, and the ends are held by a piece of skin tied to the top of the centre rod. The point or drill is a piece of shell tied on with a piece of wet skin which in drying contracts. The motion, which is backwards and forwards, is obtained by holding and working the cross bar up and down with one hand; this was in use among the Pueblo Indians of New Mexico. The same pattern is now used by saw-piercers, jewellers, and china drillers, the only difference being that they are made with a steel downrod and a brass whorl, the cross bar being connected by a thin cord. A similar drill used by jewellers, called a centrifugal drill, is arranged to turn continually in one direction, and instead of a solid brass whorl, they have a bar going through the down rod with a solid brass ball at each end, and the motion is obtained by the same action as in the Archimedean drill in Fig. 6, No. 9.

Fig. 6, No. 7, is a wood brace, made in 1760, to be seen in the Pitt-Rivers Collection at Oxford.

Fig. 6, No. 8.—This is a bow or fiddle drill of wood and of Indian manufacture. It is modern work, nicely made, and of good shape. The cutting edge of the drill is peculiar, as it is in the form of a vee, so it has a scraping action when in use. This form of drill stock is at the present time largely used for certain work, and it is called a fiddle drill. In the above-mentioned collection at Oxford some primitive lathes based on this form of drill are to be seen. There is no doubt that this form of drill suggested our lathes, through such



Nº 1. Bone Perforator used in Neolithic Age
Nº 3 Bow drill from the Sculptures at Thebes
Nº 5
Nº 2 Fire Drill used by being twirled between the hands for producing fire and incidentally boring a hole
Nº 4 Drill used for making holes in stone
SECTION OF CANE AND STONE
FED WITH SAND AND WATER
Mouth or Strap Drill for fire making
Examples of Drilling Appliances from the Earliest Specimens Known.
Nº 8 Bow drill with socket handle spindle drill and bow Indian.
Wooden Brace used about 1760
Nº 6 Pump Drill with wood whorl and shell point
Nº 9 Archimedian Drill Stock
SQUARE TAPER HOLE
Nº 10 Modern Drill Stock.

FIG. 6

forms as the old tree lathe, the spring pole lathe, and Berson's lathe, all which work on the same simple principle.

Fig 6, No. 9, is the simplest form of an Archimedean drill, named, it need hardly be pointed out, after the supposed inventor of the screw, Archimedes, who lived 250 B.C. This drill stock is of square iron twisted, and the travelling hand-piece of gunmetal is cast on. The top works on a tenon on the twisted rod. The bottom of the rod has a square hole to hold the drills.

Fig. 6, No. 10, shows a modern hand or breast drill geared to two speeds. It has a universal three-jaw chuck to hold the drill. The original ones of this pattern were called Millar's Falls drills, after the place where they were made. In addition to the above drills and materials used as drills, operations have revealed that tubular drills set with emery were used in ancient Egypt. Needless to say, diamonds have replaced emery in the modern development of the tubular drill.

CHAPTER XV

SUPPLEMENTARY PROCESSES AND DATA FOR OBJECT LESSONS ON METALS

HARDENING AND TEMPERING OF METALS.

THIS may be accomplished in many ways according to the nature of the material. Nearly all metals can be hardened by rolling, hammering, stretching, bending, or by the addition of other metals. They can also be annealed or softened by heating to various temperatures and subsequent cooling. The longer steel is in cooling, within reason of course, the softer it becomes. What is known as spring brass, hard-rolled copper, and hard-rolled phosphor bronze, are hardened by rolling. Wrought iron and mild steel can be hardened by case hardening, i.e. the surface or skin is hardened and the interior left soft. This is a most useful combination in many instances. It is done as follows: The article to be case hardened is placed in an iron box containing substances rich in carbon, such as powdered charcoal, horns, bones, leather cuttings, etc.; the box is then luted up with clay and made airtight, put into a furnace and kept at a red heat until the objects have absorbed sufficient carbon. This may take from one hour upwards. The objects are then dumped into a tank of water which is kept agitated. Small objects may be case hardened by heating to a red heat, then rolling in yellow prussiate of potash, which fuses on the surface; on being reheated the mass is quenched in cold water. This operation has to be repeated until the necessary hardness is obtained. Cast iron can only be hardened by being chilled.

Carbon Tool Steel can be hardened, tempered, and annealed, and these properties make it universally useful. It can be hardened by heating to a bright red heat and quenching in water, brine, oils, fat, wax, lead, and mercury. But the various kinds of *tool* steel vary as to the heat required to obtain the best results. Tempering is bringing the hardened steel to a temper or proper degree of hardness or toughness by reheating after hardening. The temper is judged by the colour of the film of oxide on the brightened surface. It is always necessary to brighten the tool after hardening. To anneal is to soften by heating and cooling slowly by burying in ashes or lime. The oxides seen in colours on the brightened surface of steel while it is being tempered are combinations of the oxygen of the air with the metal.

Non-Tempering Steel.—This is simply carbon tool steel which is used for chisels and like tools; it is hardened by dipping right out in cold water from a cherry red, and as the name implies it does not have to be tempered.

Point hardening is a method sometimes adopted for hardening chisels and similar tools and is conducted as follows: The chisel is heated for about 2 in. from the cutting edge; the point is placed in water to a depth of three-quarters of an inch until cold; the chisel is then taken out and the point is rubbed with a piece of grit stone until bright; the heat from the remaining portion runs back to the point, and when the cutting edge is the right colour it is cooled right out. In oven tempering, ovens are used for tempering tools right through and in some cases is preferable. The ovens are very reliable and can be heated to any known degree of temperature. In small shops where expensive appliances are not available, tempering is done with a gas blowpipe or on a sand bath, which is very useful and simple. A metal box is filled with fine sand and placed on the fire or a gas stove The tool is hardened and brightened and then laid in the hot sand and turned over and over until the correct temper is obtained. Another method is to heat a piece of iron and lay the tool on it. Lead, tin, and bismuth, alloys are also used. A bath of the molten metal is made and the articles to be tempered are immersed in it. The molten metal can be tested with a pyrometer and very accurate tempering can be accomplished. For very small tools a piece of pipe can be made hot and the article held inside until the right colour is obtained. Self-hardening or air-hardening steels owe their hardness to the presence in them of chromium, tungsten, or molybdenum. They are forged at a bright red heat, and to harden them the cutting edges of the tools are heated to a white glassy heat and cooled by a blast of cold air. This treatment would ruin ordinary carbon tool steel.

Tempering Scale.

Colour of Oxide.	*Tools.*
Light yellow	For files, scrapers, engraving tools, and lathe tools for hard cast iron and steel.
Yellow	Lathe tools, dies, planer tools for iron.
Dark yellow	Milling cutters, dies, punches
Brown	Taps, cold chisels, shears, scissors.
Dark brown	Centre punches, scribers, drills for brass.
Brown with purple spots	Axes, planes, twist drills.
Light purple	Chisels for cast iron, large shear blades, table knives cold sets, saws for metal.
Dark purple	Hand and pit saws, screw-drivers.
Dark blue	Springs.

METHODS FOR DISTINGUISHING TOOL STEELS FROM MILD STEELS AND WROUGHT IRON.

By fracture or examination of the grain—

Wrought Iron has a rough fibrous fracture. Good quality wrought iron has a fine fibrous fracture. Outside appearance is of a dull black colour with reddish scale.

Mild Steel has a grey-white colour with small polished grains intermixed and not fibrous like wrought iron; inclined to be granular and silky in appearance. Outside appearance is of a bright black colour.

Cast Iron has a dull grey granular appearance, and the grain varies according to the quality. The finer the grain the better the quality.

Tool Steels have a grey-white granular appearance, and the better the quality of the steel the finer the grain, until with air hardening steels the grain has a silky appearance. Outside appearance is of a very bright blue-black colour.

Shear Steels have a coarse granular appearance with white faceted grains closely mixed, and it does not break with such a clean fracture. These steels can be welded.

Burnt Iron or Steel is very brittle, coarse grained with very bright facets mixed with dull grains.

To fracture the metal, nick it with a chisel, file, or emery wheel, then break it

DOUBLING OVER TEST.—If wrought iron is doubled over on itself and then hammered flat at the bend it will partly break open and show the fibre; mild steel does not break when treated in this manner.

DROP TEST.—**Tool Steels** have a very high-toned ring when dropped on a stone floor. The harder the steel the higher the note.

Mild Steels and **Wrought Iron** have a lower tone and a dull ring.

Cast Iron has a very dull and dead sound.

HEAT TEST.—Heat to a bright red and quench out in water, then try it with a file; if it cannot be filed it is carbon tool steel.

SPARK TEST.—Hold the piece of steel on a dry emery wheel and notice the colour and shape of spark.

Mild Steel.—A long, narrow, and bright spark.

Tool Steel.—A bright star-shaped spark.

High Speed or Alloy Steels.—A dark red pear-shaped spark.

High Speed Steel can hardly be filed at all when in its natural state, as it is very hard.

The methods above mentioned are rough and ready, but the necessary apparatus for testing in the proper manner is not always to hand.

Warping and Cracking of steel is caused by improper treatment when being forged, insufficient annealing (setting up internal strains), not heating thoroughly when preparing for hardening, or heating too quickly.

Warping in hardening is caused by one side of the article being cold before the other, or the thin side becoming cold before the thick side, so distorting the object.

CASTING OR FOUNDING

is the art of working metals by pouring them while in a fluid condition into moulds where they solidify and harden into the form of the mould they fill. It is the most important of the operations by which metals are fashioned into ornamental and useful forms, although in practice some metals cannot be cast. It is an art that has been known and practised from very early times In the Victoria and Albert Museum there is some cast bronze coinage belonging to the Chou dynasty dated 1122-1225 B.C. In the room of Greek and Roman life at the British Museum there is a limestone mould for casting metal which was in use about the eighth century, B.C., a bronze mould for palstaves (a kind of axe), and a stone mould for casting hammer heads. This last is illustrated in Ch. XIV, f. 4. Nos. 8 and 9 on the same page are bronze castings of an early date

There are many operations in casting, and the article to be produced is now seldom made, moulded, and cast by one man, as was the case when Benvenuto Cellini modelled his figure of Perseus, and directed and helped in the casting of it. The most important operations in casting are making the pattern, making a mould from this in sand or some other suitable material, and melting and pouring the metal into the mould Patterns are usually made outside the foundry or in the patternmaker's shop, quite distinct from the foundry. It is a woodworking trade, and the pattern-maker should have a knowledge of metals and of foundry practice. Iron is practically always cast in an iron foundry, while all the non-ferrous metals and alloys are cast in what is called a brass foundry. The tendency of the times is to specialize in one particular metal or group of metals, and by so doing better castings at a cheaper rate are obtained. Patterns are made either in metal, wood, plaster of Paris, or wax. Patterns which must be hollow have cores made of sand and shaped in core boxes. Moulds for casting metal are made of sand, metal, or a mixture of plaster of Paris and brick dust. When sand is used it is contained in an iron frame called a flask; this flask consists of two iron frames which fit together with pegs and eyes, the pegs on one frame the eyes on the other. There is green-sand moulding which is moulding in sand that is not dried, and dried sand moulding, where the mould has to be dried or baked in an oven. Large iron castings are cast in a loam mould, which is often made by being "swept up". When the object is circular a piece of flat wood made to the shape required and pivoted on a centre rod and revolved against a mass of sand cuts or "sweeps up" the mould. Cores are also made by sweeping up.

When the surface of an iron casting is wanted extremely hard, as in the case of car wheels, or rolls, this part of the mould is made of iron, so that when the molten metal flows against the cold iron it is chilled and hardened. Sand, owing to its cheapness, porosity, and refractoriness, is the best and most convenient material for moulding. Its porosity allows for the escape of the gases generated, while its refractoriness keeps it in shape when the molten metal is poured into the mould. The best moulding sand is found along the banks of large rivers. For repetition work moulding machines worked by hydraulic power or by hand have displaced hand moulding and are now largely used.

Another method of casting, known as "Cire Perdu" or the lost wax process, is used for the best class of figure work, not the bronze figures one sees sold with clocks and marked at £2 17s. 6d. the set. These are mostly cast of zinc or antimonial lead, in what is known as a slush mould. A good illustration of the lost wax process is shown in the Indian section of the Victoria and Albert Museum. It is a sand mould containing a cast brass curb chain anklet; a model of the anklet is first made in wax, each link being unconnected with the others except by a narrow band along the top. The model is gradually encased with the liquid composition which forms the mould; the metal is deposited in a crucible attached to the mould and the whole is placed in the fire. The action of the fire destroys the wax model, the wax being absorbed into the mould, which then retains a complete impression of the anklet, each link being separate from the other with the exception of the narrow band at the top. When the metal is ready the whole affair is reversed, the hot metal fills the impression left by the wax model, and when the band connecting the links is filed off the anklet is left in the form of a chain. This object is from Rajputana. The candlestick on p. 94 is an example of cast and turned work, and the method of making it is shown on the page following.

Castings and wood patterns showing how the patterns would be made for various objects are illustrated in Chs. VII and IX.

The Dutch chandelier (Ch. XII, f. 8) is a good example of cast and turned work. The handles (Ch. V, f. 6, Nos. 10, 11, 12) would have to be modelled in wax and then cast in plaster, or carved in wood. It would be better to have these cast in "fine cored brass," that is, the mould would have to be faced with some very fine parting compound such as French chalk, which gives a fine outer surface to the finished casting, and cored. It is cored by having small pieces of moulding sand fitted to the various undercut parts so that they will come away and the pattern be withdrawn and then the pieces of sand called "false cores" are replaced so that the mould is perfect and ready for receiving the metal. The majority of patterns received by founders from artists are in plaster, and off these plaster patterns piece moulds are made in sand.

The metal used in an iron foundry is usually melted in a cupola furnace, but other metals than iron are melted in crucibles which are placed inside a furnace heated by gas, coke, or oil. Modern furnaces are mostly heated by gas or oil, and can be tilted so that the metal may be poured into the ladle or mould direct, thus saving the trouble of lifting the crucible full of molten metal out of the fire by manual labour. Crucibles are made of plumbago, graphite, fire clay, etc. The plumbago crucible consists of equal parts of clay and graphite. Owing to the great differences in characteristics and faults which are inherent in the metals themselves, a knowledge of metallurgy is very necessary for the successful casting of metals. The most common faults in castings are :—

Blow Holes, caused by the gases not getting away.

Overshot Castings, caused by badly fitting flasks.

Oval Castings instead of round, owing to the moulds being pinched together too lightly.

Seared Castings, caused by the mould being too hard and not allowing the metal to shrink.

Imperfect Corners, owing to the metal being poured at too low a temperature or the corners of the mould not being pricked to allow the metal to run up sharp.

For the shrinkage of metals in castings see pp. 127-128.

CLEANING, FINISHING, AND PRESERVING OF METALWORK.

Many of the articles shown in these pages could be made of brass, bronze, copper, German silver, or similar metals, and it must not be forgotten that finish is most important, but this depends on the possession of good taste by the maker. The finish chosen must suit the object and its surroundings. The colour should be uniform and beautiful and should be consistent with the metallic character of the work. The necessary steps to be taken for preparing the work ready for colouring or finishing are numerous. Thorough cleaning is carried out in the following manner: The object should be held by a piece of copper or brass wire, or by brass tongs, etc., so that it is not stained by the hands. It is then boiled in a solution of caustic soda (1 lb. to the gallon of water) to remove all grease, dirt, or old lacquer. [N.B.—Articles of aluminium, tin, or zinc must be treated with care, as they may be partially dissolved by this liquid.] The object is then well scoured with fine wet sand and well washed in running water. It is placed in pickle to soak for one to three hours, according to the strength of the pickle. (This is spent. dip with water added.) Then it is washed and scoured with sand and water, washed again in cold water then passed through boiling water. It is then run through the old dip, then through the bright dip, through three washing waters, and finally through boiling water. It is necessary that the object should be quickly dried, and this drying is done by shaking it about quickly in plenty of hot sawdust.

The above applies to all copper, brass, bronze, and similar metals. The object is now ready to be bronzed, as described on p. 154, scratch brushed, polished, or electroplated. For scratch brushing a brush made of fine brass wire is required. Hand or lathe scratch brushes can be bought. The work is brushed with this and stale beer or water and vinegar. It is then well rinsed in two washing waters, finally in hot water, and dried in hot sawdust. It can now be relieved or lightened up by burnishing with a steel, agate, or bloodstone burnisher and stale beer, wiped off and lacquered. If the object is to be polished, it may be pressed against a revolving calico or other mop or bob fixed on the spindle of a polishing head which revolves at a very high rate of speed. The mop or bob may be of leather (rhinoceros or wairus hide, which is sometimes called bull neck), felt, calico, or wool, and fed with carborundum, emery, sand, bathbrick, tripoli, rouge, lime, tallow, etc. Mops or bobs are made in various sizes, but are not usually larger than about 12 in. diameter and 2 in. thick. After being polished the work is usually greasy. The grease is removed by washing in two or three baths of paraffin or benzene. Nearly all metalwork after finishing and colouring should be lacquered. Lacquering may be accomplished by dipping the article into a vat of lacquer and drying in a special room or oven, by putting the lacquer on with a brush when the work is hot or cold (depending on the lacquer), and drying, or by spraying the lacquer on with a patent air spray or brush as it is called. Lacquer is a thin spirit varnish made in various colours. It is generally shellac dissolved in alcohol and coloured with dragon's blood, turmeric, saffron, etc. What are known as cold lacquers (all of which are patents and go by fancy names) are made with amyl acetate and coloured with aniline dyes. Many of these lacquers smell like essence of pears. It is essential that the work should be free from all dirt, dust, grease, etc., before being lacquered. Skill and artistic taste are required for the blending and lacquering of metallic objects. Figure work is sometimes brushed over with white paraffin wax or beeswax.

Iron and steel articles, structures, etc., are preserved from rusting by gilding, painting with oil colours, or coating with another metal which is not affected by the atmosphere, such as tin, zinc, copper, nickel, etc. Before being protected by painting, ironwork should be heated sufficiently to dispel all moisture, and while hot should be painted with a coat of boiled linseed oil applied at a boiling heat. After twenty-four hours this operation should be repeated, and then the colour coats applied, or it may now be gilded after the necessary sizing. Tin plate is wrought iron or mild steel sheets, thoroughly cleaned, passed through a bath containing molten tin with about 4 in. of tallow on the top, then through rollers which squeeze off the surplus tin. The plates are dried in bran. Iron is galvanized or coated with zinc by hot galvanizing, electro galvanizing, Sheraidizing, or dry galvanizing. For hot galvanizing the work is cleaned by sand blasting, pickling in hydrochloric acid, or burning. It is then passed through a bath of molten zinc, and allowed to cool. Work preserved in this manner can be distinguished by its spangled appearance. Electro galvanizing is done in a similar manner to the electro deposition of other metals (see p. 155), but owing to the difficulty of depositing zinc, slight modifications are necessary. The Cowper Coles process is most successful for this work. Sherardizing is a process invented by Mr. Sherard Cowper Coles, and is somewhat as follows: The work is cleaned as previously described and then placed in an airtight drum charged with zinc dust. This is rotated and heated to 500° or 600° F. for a few hours and allowed to cool. When removed the articles are found to be coated with zinc depending in thickness upon the temperature and duration of the treatment. They are of a brighter colour than articles done by the electro deposition method.

It is possible by this method to galvanize only certain parts, by coating portions of the articles with a composition which prevents the zinc being deposited.

The following are a few simple and useful recipes for general work :—

Bright Dip for Iron —

Water	1 gal.
Sulphuric acid	1 lb.
Zinc	1½ oz.
Nitric acid	8 oz.

Bright Dip for Brass, Copper, and Similar Metals —

Nitric acid	2 parts.
Sulphuric acid	1 part.

Hydrochloric acid ½ pint per gal. of dip.

Matt Dip for Brass, etc. – Dissolve 6 oz. clean sheet zinc in 1 gal. hot nitric acid, then pour in sulphuric acid slowly until dip looks white, then heat to 160° F. and test; if too coarse add sulphuric acid. Stir with glass rod; never use wood, and don't put hydrochloric acid in it.

Removing Copper Oxide from Brass after Brazing.—Old bright dip heated to 150° F., then add 2 qts. of sulphuric acid for every gallon of bright dip.

To Copper Wire Nails or Iron Screws —

Blue vitriol	1 oz.
Sulphuric acid	1 oz.
Water	1 gal

To Boil Brass Articles White.—Put 8 oz. pure tin shavings and 6 oz. cream of tartar into a boiling pot with 1 qt of water. Make sufficient to cover the work and boil.

Various Shades of Brown on Brass, etc. :– See p. 154.

Various Shades of Brown, including Brilliant Shades of Blue —

Hyposulphite of soda	4 oz.
Acetate of lead	2 oz.
Water	1 gal.

To be used hot and each chemical to be dissolved separately.

Green Bronze :—

Ammonium carbonate	2½ oz.
Common salt	¼ oz.
Acetate of copper	1 oz.
Cream of tartar	¾ oz.
Water	16 oz.

Brush the work over with this and let it dry. Repeat until the right colour is obtained.

Steel Colour on Brass:—

Arsenic	½ lb.
Blue copperas	4 oz.
Carbonate of iron	2 oz.
Verdigris	2 oz.
Hydrochloric acid	7 lb.

Immerse, wash off, scour with sand, and repeat until a good colour is obtained, then brush up with blacklead.

The procedure for the above cases is similar in nearly all. The work must be thoroughly cleaned and dipped bright and then immersed in above solutions. To obtain the best results a little practice is essential.

Surface colours or patinas may be obtained—

By chemicals as above.
„ heating.
„ oxidizing or atmospheric influence.
„ alkalis.
„ electro deposition.
„ dipping in molten metals.
„ varnishing or lacquering.
„ rolling, that is, soldering a thin piece of metal on to a thick base and then rolling all out together; examples: Sheffield plate, rolled gold.

METHODS OF JOINING METALS.

In all kinds of metalwork a knowledge of how metals may be joined together is essential. Joints are either permanent or temporary. Permanent joints can be made by burning, autogenous welding, ordinary welding, brazing, silver soldering, soft soldering, folding, riveting. Temporary joints are screwing, bolting, wedging, taper fitting, force and shrink fitting. In many cases, though we call brazing, silver soldering, soft soldering, and riveting *permanent* joints, they can with care be taken apart again.

Burning.—The method of burning a joint together is as follows: The two pieces of metal to be joined are placed in position and fixed so that a stream of molten metal may be run between the joint until the ends to be joined are at the same heat; the molten metal that has been flowing to waste is then checked, the joint filled up and left to cool. The joint is usually embedded in sand. When cool it is removed and the lumps trimmed off, leaving the metal in one piece and without any sign of a joint. Nearly all metals can be joined by this method.

Autogenous Welding, or thermit welding, is done as follows: Thermit, which consists of finely divided aluminium and oxide of iron, is placed in a crucible which has a hole in the bottom fitted with a fusible plug. The crucible is placed in position over the ends to be joined, and the ends are enclosed in a mould which has an outlet that can be closed after sufficient metal has passed through to heat the joint. When everything is ready the fusing action is started by igniting a special powder, or magnesium powder, which can be lit with a match. The heat generated by the chemical action reduces the iron oxide to a fluid mass of iron; this melts the fusible plug, allowing the metal to enter and fill the mould. This is also called aluminothermy.

Blowpipe Welding is carried out by means of various gases, such as acetylene, oxygen, hydrogen, and is now fairly general in its application. The gases are under pressure and drawn from cylinders. The mixing of them takes place in the mixing chamber of the special blowpipes which are used. The edges of the metals to be joined are filed clean and bevelled, and while the fusion of the edges is taking place the actual joint is fed with a metal of the kind that is being welded, in the form of rod, to fill up the spaces in the joint. The advantages of this method are that the appliances are portable, so that welds can be made "in situ" and the heat is localized. The perfection of the weld depends on the skill of the operator.

Electric Welding is very suitable for repetition work, is very quick, and dissimilar metals may be welded. But it requires special plant and fittings for each particular job. The operation is somewhat as follows: The pieces to be welded are held tightly one by each arm or guide, and these are insulated one from the other; the electric current is turned on, and the ends are brought close together but not quite touching. This causes an electric arc to form at the ends to be welded, and they heat from the centre to the outside, and when it is at the right temperature, the ends are forced together either by manual or hydraulic power.

Ordinary Welding which is done by the smith consists of thickening up or up-setting, as it is called, the ends to be joined to allow for their subsequent reduction by hammering and then raising the pieces to a welding heat, laying one on top of the other, and hammering them together. The work is heated in a coal or coke fire assisted by a blast of air. Wrought iron and mild steels are usually brought to a bright white heat and tool steel to a dull white or yellow heat. There are various forms of welds such as scarf welds, tongue welds, split welds, and jump welds, but the scarf weld is the strongest and most common. A flux is generally used to protect the surfaces of the metal to be joined from the action of impurities in the fuel and from oxidation—silver sand for wrought iron and mild steel, venetian red and borax for tool steels.

Brazing and Soldering consists of joining metals by means of alloys which are heated and fused together with the edges of the work, so that they alloy with the metals being joined. There are three essentials for this kind of work.

The joints must be clean.

A flux must be used.

The solder or alloy used must melt before the material that is to be joined.

A coal-gas blowpipe flame assisted by an air blast is generally employed, but a forge fire, or spirit blow lamp would very often answer the same purpose. The only difference between brazing or hard soldering, as it is sometimes called, and silver soldering, is that in the one case spelter is used and in the other silver solder is used. (For the composition of these see p. 124.) The following method of procedure should be adopted when brazing or silver soldering. The joint should be clean and the edges fit together. When fitted, the parts should be held together by ties of iron binding wire, when the joint is difficult to adjust one or more iron dowel pins should be used. These with the wire ties prevent any shifting of the joint during the progress of the operation. The work should now be carefully adjusted on the bed of the forge, care being taken to support it so that no strain is on the tied joint. When arranging the coke around joint to conserve the heat, place it so that all the parts are open to observation, otherwise while the solder is fusing, some adjoining part may be melted. The difference of the melting temperatures being very slight, spelter should be mixed with water and powdered borax in a small pot. When the work is in position the joint should be moistened with the borax water and the joint "charged," i.e. just sufficient of the moistened spelter laid on the joint to fill it when fused. The work should now be heated in the vicinity of the joint, and when there are unequal thicknesses the heaviest parts should be heated first, gradually bringing the heat up to the joint; watch that both sections receive the same amount of heat, otherwise it will not be a good joint. When a red heat is reached the borax will melt; dry powdered borax should now be dusted on from time to time to prevent the solder perishing or being converted into oxide; as the heat increases the flame should be localized over the solder and a fiercer blast given until the spelter fuses and flows into and fills up the joint. When this point is reached remove the flame and allow the work to cool. It should not be moved until all traces of red heat have disappeared; then place in pickle (for composition of this see p. 177) to dissolve the borax and oxide.

Soft Soldering.—This consists of well cleaning the parts to be soldered, applying a suitable flux (for this see p. 188), heating the metal, and applying just sufficient solder to make the joint. Soft soldering must be done with the aid of a soldering iron or bit (see Ch. XVI, f. 16), spirit lamp, gas blowpipe, or heat of some kind to melt the solder. When using a soldering iron or copper bit, as it is sometimes called, it must be well tinned, that is, the iron must be heated, filed clean, rubbed in the flux, and the point covered with solder. It is very often an advantage to tin the parts to be soldered first.

Zinc Chloride for Soft Soldering.—Place some pieces of zinc in hydrochloric acid until the acid stops working, then leave it for twenty-four hours. Now strain and filter it, and add 2 oz. of water to the pint of acid.

In **Riveting**, pieces of metal are joined together with rivets. These are made of various metals and in different shapes, such as half-round or snap head, pan, countersunk, flat, or conical head. A rivet is known by the shape of the head, length of stem under head, diameter of stem, and the metal it is made of.

The method of riveting is as follows: The rivet is selected according to the thickness of the plate to be riveted, the holes for the rivet are then either punched or drilled, the rivet is placed in position and the metal set down with rivet set; sufficient length of rivet is left to project through the plate and form the other head; the end or tail of the rivet should be flat, the tail should be burred over with a light hammer and finished to shape with the aid of a cup tool. For illustrations of rivet set and cup tool see Ch. xvi, f. 21 (27). The distance of one rivet from the other is known as the "pitch," and depends on the nature of the work.

Screwing is joining metals together with screws and should be avoided, as screws are liable to work loose. They are made of iron, brass, bronze, or steel, and have heads of various shapes, half-round heads, countersunk heads, cheese heads, half-round and countersunk combined. All screws used for metal are known as tapped screws or metal-thread screws to distinguish them from screws used for wood. They are made to many standards and in various pitches.

The pitch of a screw is the distance it will move in the direction of its axis in one revolution through a fixed nut. The following are some of the standards: Whitworth, British Association, known as B.A., U S.A., International Metric, and Bicycle standard. Screws are known by their diameter, standard, shape of head, metal, and length under head, as for example ¼ in. Whitworth round head, brass, 1 in. underhead. In screwing work together the part that takes the head of the screw has a clearing hole in it, while the other part has to have a tapping hole; this is also known as the core diameter so that it can be threaded. This allows the work to be drawn tightly together. In engineering shops the screws used in machinery for imparting motion are known by their shape such as "square," "buttress," "knuckle," or "acme thread". A set or grub screw is one that has a point and no head, but a saw cut in the screw itself, so that it can be turned with a screw-driver.

Bolting and Wedging is used mostly for fixing together various parts of machines. Bolts are now usually made to the Whitworth standard. The size of the head bears a fixed relation to the diameter of the bolt. There is a large variety in use, such as hexagon, ball, cheese, coach, deck, square, countersunk, etc., the name applies generally to the shape of the head. When an extra long bolt is required a "bolt end" is welded to a length of rod, as this is more convenient. Where there is a lot of vibration "lock nuts" have to be used because ordinary nuts work loose. Of these there are many forms. Wedging, keying, and taper fits are due to frictional contact, and in the fixing of nearly all wheels and pulleys this property is utilized as well as in what are known as friction clutches. The system adopted by the Morse and other companies for holding drills of all sizes by means of taper fits and removing them by means of a hand lever is an extremely simple and convenient method in every way.

A **Force Fit** is where the pin is made very slightly larger than the hole and the two parts are forced together. An example of this is the lathe pulley

TABLE SHOWING METHOD BY WHICH METALS MAY BE JOINED.

Name of Metal.	Soft Soldered.		Silver Soldered		Brazed.		Autogenous Soldering or Burning, including Oxygen Acetylene Welding.		Welding, Old Method.	
		Flux		Flux		Flux.		Flux		Flux.
Aluminium . .	No	—	No	—	No	—	Yes	None	No	—
Aluminium bronze	Yes (after being coppered)	Zinc chloride or Sal ammoniac	Yes	Borax	Yes	Borax	No	—	,,	—
Brass . . .	Yes	,, ,,	,,	,,	,,	,,	Yes	Borax	,,	—
Britannia metal .	,,	,, ,,	No	—	No	—	No	—	,,	—
Bronze . . .	,,	,, ,,	Yes	Borax	Yes	Borax	Yes	Borax	,,	—
Copper . . .	,,	Zinc chloride, Sal ammoniac, or Rosin	,,	,,	,,	,,	,,	Borax	,,	—
Delta metal . .	,,	,, ,,	,,	,,	,,	,,	No	—	,,	—
Dutch metal . .	,,	,, ,,	,,	,,	,,	,,	,,	—	,,	—
German silver .	,,	,, ,,	,,	,,	,,	,,	,,	—	,,	—
Gilding metal .	,,	,, ,,	,,	,,	,,	,,	,,	—	,,	—
Gold . . .	,,	,, ,,	,,	,,	No	—	,,	—	,,	—
Gunmetal . .	,,	,, ,,	,,	,,	Yes	Borax	Yes	Borax	,,	—
Iron, galvanized .	,,	Hydrochloric acid	No	No	No	No	No	—	,,	—
Iron, wrought .	,,	,, ,,	,,	,,	Yes	Borax	Yes	None	Yes	Silver Sand
Iron, cast . .	Yes, not strong	Zinc chloride	,,	—	No	No	,,	Borax	No	—
Lead . . .	Yes	Zinc Chloride or Tallow, etc.	,,	—	,,	,,	,,	None	,,	—
Manganese bronze	,,	,, ,,	Yes	Borax	Yes	Borax	No	—	,,	—
Mild steel . .	,,	,, ,,	,,	,,	,,	,,	Yes	None	Yes	Silver Sand
Muntz metal . .	,,	,, ,,	,,	,,	,,	,,	No	—	No	—
Ormolu . .	,,	,, ,,	,,	,,	,,	,,	Yes	Borax	,,	—
Pewter . . .	Yes, but using special solder	Tallow or Gallipoli oil	No	—	No	—	No	—	,,	—
Phosphor bronze .	Yes	Zinc chloride or Sal ammoniac	Yes	No	Yes	Borax	,,	—	,,	—
Silver . . .	,,	,, ,,	,,	,,	No	—	,,	—	,,	—
Tin . . .	Yes, with care	,, ,,	No	—	,,	—	Yes	—	,,	—
Tinned plate. .	Yes	,, ,,	,,	—	,,	—	No	—	,,	—
Tool steel . .	,,	,, ,,	Yes	Borax	Yes	Borax	Yes	None	Yes	10 Borax, 1 Sal ammoniac or Borax and Venetian Red
Zinc . . .	,,	Zinc chloride, Sal ammoniac or Hydrochloric acid	No	—	No	—	No	—	No	—

Note.—When rosin is mentioned Venice turpentine will do as well, and is cleaner.

Ch. XVII, f. 22 (1). This pulley of cast iron is forced on to the steel mandrel, or lathe spindle as it is called. This appears as if made in one piece.

A Shrink Fit is where advantage is taken of the property of expansion of metals, and it is utilized in many ways. The method is used where a collar has to be put on some work to hold it together. The collar is made slightly smaller than the work it has to go on, it is heated to a bright red and put on. On cooling it contracts, so binding the work tightly together. Cast iron cannot be utilized in this manner. For example see Ch. XII, Fig. 12, No. 1.

Joints in Tinned Plate Work.—These are usually plain or folded lap joints (see A and B, Fig 8, Ch. VIII) The plain lap joints are soft soldered and riveted with tinned iron flat headed rivets. Folded lap joints, as illustrated in Fig. 8, Ch. VIII, Letter B, can be made by hand or in a machine called a folder, and when made by machinery they are so well done that they are watertight without the aid of soft solder.

HINTS WHEN WORKING METALS.

Annealing Metals.—

1. Anneal zinc with a Bunsen burner, not a blowpipe, or it may volatilize.
2. When annealing aluminium mark over with common soap and warm until soap turns black; it is then annealed.
3. Before annealing sheet brass work ease any stresses that may exist by malleting. Also warm very slowly and gradually increase temperature to avoid fire cracks

Soldering Metals:—

1. All metals should be tinned at the joint before being soft soldered.
2. Use hydrochloric acid as a flux when soldering galvanized iron.
3. Before soft soldering pewter be sure the solder melts before the job.

Brazing Metals:—

1. Iron should be reddened before being brazed, i.e. rubbed with sulphate of copper (bluestone) and water.
2. File all joints before brazing and silver soldering.
3. Butt joints should be nicked before brazing.
4. If spelter is not fusible enough add zinc filings or a little silver solder.
5. Before brazing sheet or rod brass, practice on a waste piece of the *same* material first.
6. See that your work is well packed up and tied before brazing so that it does not separate when on the point of fusion.
7. See that there is not any lead or solder on brass when bringing the brass to a red heat as it will cause a hole.

Forging:—

1. Keep the fire clean, and free from clinker.
2. Keep the face of your hammer in good condition.

3. See that your tongs fit the work, so avoiding an accident.

4. Do not work iron at a dull red heat.

5. Do not work or heat carbon tool steel beyond a bright red heat.

6. When cutting material on the anvil with a hot or cold sett see that the tools do not touch the face of the anvil when nearly through.

7. A block of copper with a piece fitting into the square hole in the anvil is handy for cutting out thin material on, especially if the material is hot.

8. Good forge coal should be even in size, glossy black, and should crumble, not split.

9. Pea-size washed coke breeze makes a nice clean fire for light work.

10. Before welding see you have all the tools ready to hand.

Other Points that you may need:—

1. Keep hammers off tin plate as much as possible; use a mallet instead, and little of that.

2. Measure twice before cutting your material off.

3. See no dampness is in or on the moulds used for casting lead in.

4. When loading brass tube for bending, see that no air-pockets form. Prevent by heating tube at loading end and work downwards with the blowpipe so allowing the material to settle; reversing the process might cause a burst.

5. Use a slate pencil for marking on iron, or a scriber made of brass wire.

CHAPTER XVI

BUILDINGS, EQUIPMENT, AND TOOLS FOR TECHNICAL AND HANDCRAFT CENTRES

THE WOODWORKING SHOP.

THE essential feature of a properly equipped workshop for technical or handcraft work is a lofty, well-lighted spacious room, so arranged as to render classrooms easily accessible, one of these if possible actually adjoining the workshop. A plan of a woodworking shop is illustrated on page 188 arranged for the accommodation of twenty students. In centres devoted exclusively to junior handcraft work, the accommodation can easily be increased to double capacity by using double benches—not necessarily any larger in size than those shown. The plan illustrated is of a shop suitable for day handcraft or technical work, which also lends itself well to evening instruction in woodworking subjects. The benches D are arranged in three rows, all facing one way. An instruction bench A is placed in the same relative position, facilitating demonstrations, and it is placed upon a raised platform B. The wall at this end should be provided with a large blackboard, not less than 6ft. square, which can be raised or lowered at will. Entrance to the handcraft room is made through the folding doors at C from the class room adjoining shop, and on the south side the handcraft room can be entered through the timber store marked D in diagram. E in plan marks the position of a small lathe (see also Fig. 22 (26)) operated by foot-power, or a small electric motor can be attached to each machine at comparatively small cost. G marks position of an oilstone table (see also Fig. 4, p. 192) for general use. F and H show position of store cupboards, the upper parts provided with glazed doors, and serving as storage space for special tools, models of tools, etc.—used for demonstration purposes—books, and a divided portion can be fitted up as a small timber museum, with specimens of timber, cross-sections of timber, leaves, twigs, etc., for use in object lessons. Students' books, drawing paper, charts, and large diagrams used in class work can be accommodated in racks and trays fitted into the bottom part. I indicates a grindstone (see also Fig. 5, p. 193). J is the plan of a gas stove with rings for accommodation of glue-pots

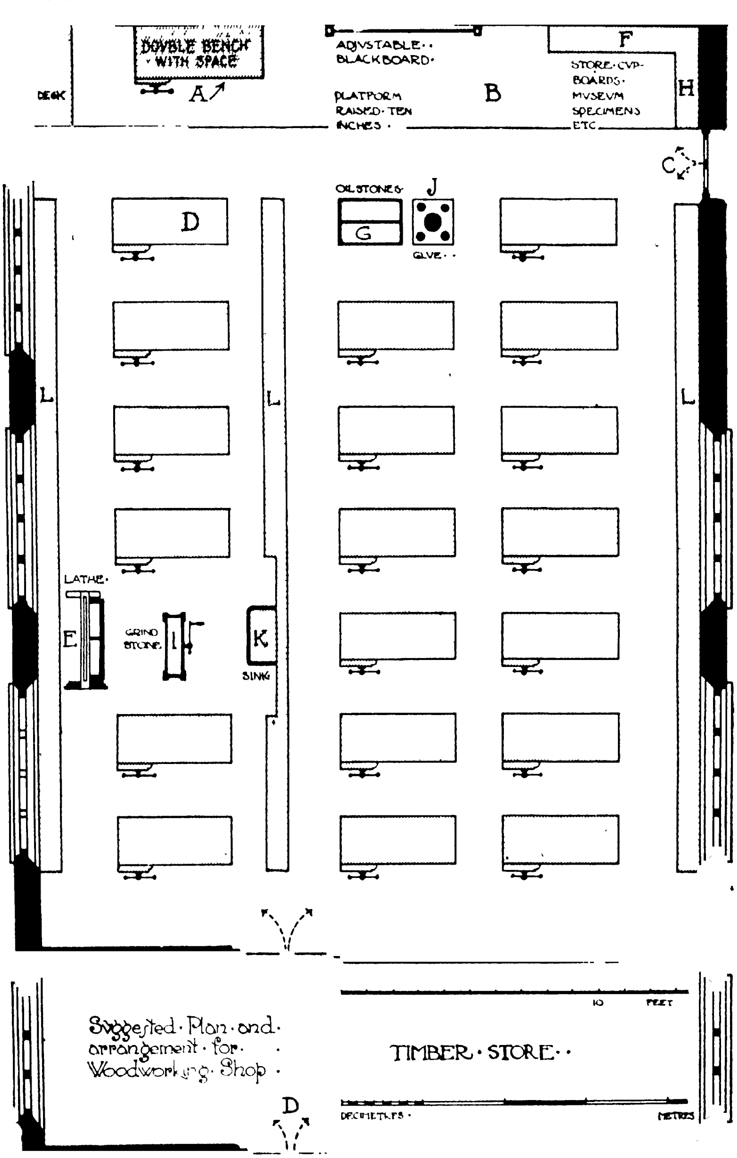


FIG. 1.—Suggested arrangement of workshop for handcraft and technical classes.

Electric power can now be utilized for this purpose. K represents in plan an earthenware sink for washing purposes.

Heating is best effected by the radiator system, with valves for regulating the temperature. Open fires should not on any account be introduced in wood-working rooms. The spirit of emulation, a much discussed and sometimes abused virtue, can be encouraged by the judicious selection and arrangement of good examples of decorative craftwork. These should be protected with glazed frames and hung about the walls about 4 ft. 6 in. high, changing them at intervals for different specimens.

Decoration, economical, and yet possessing some æsthetic merit, should be carefully studied in institutions which aim at the development of taste. Distemper colours are good, as they can be readily renewed, preferably light green or grey tones, these being more suitable to the eyes than crude or vivid colours which are so conducive to eye-strain. Ventilation is readily effected by means of iron casements, now an accepted type of window for school buildings. Air bricks with adjustable covers are also an advantage.

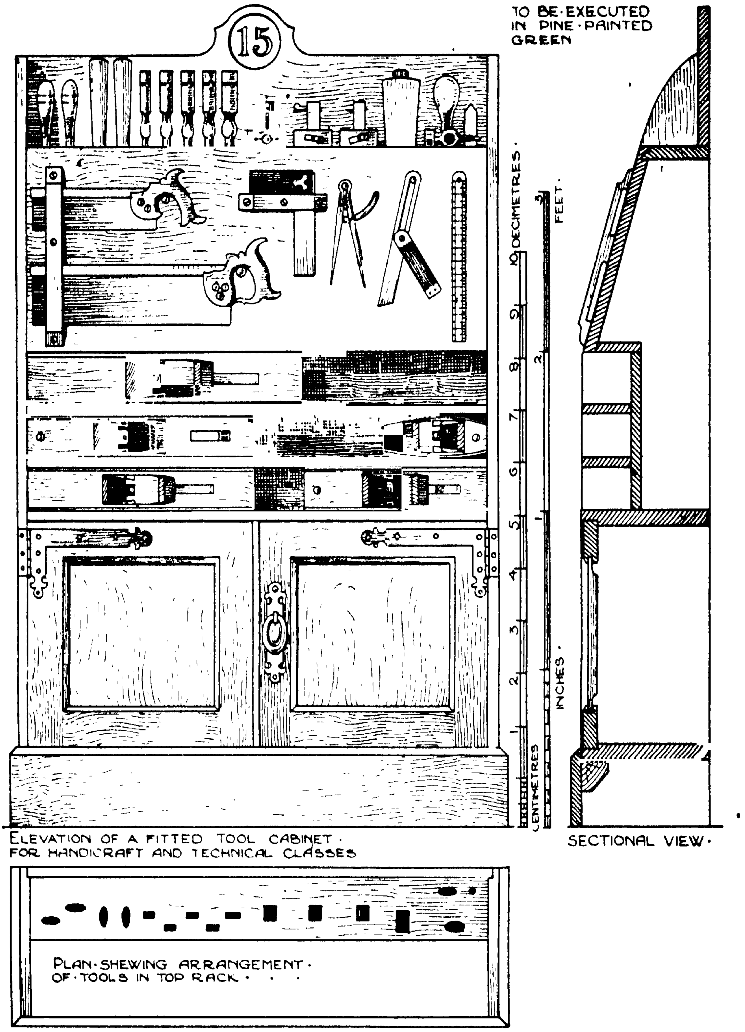
Flooring.—Parquetry or wood floors of pine or yellow deal are preferable to those made of teak wood, affording a better grip for the feet and not becoming slippery so rapidly. Projecting portions of tool cabinets placed round the walls should be avoided; a good plan is to fit pieces between the tool cabinets at an angle of 45° with the wall and floor lines, thus avoiding accumulation of dust in corners and rendering sweeping and cleaning much easier than would otherwise be the case.

Tool Cabinets.—The particular design and arrangement of these of course varies according to conditions, but the examples illustrated will serve as first suggestions which can be adapted to other requirements. That illustrated in Fig. 2 is designed to serve for both junior pupils and evening students in technical work. The material is whitewood, painted to harmonise with the wall treatment. The arrangement of the tools will be apparent from the diagram, a set of small planes for juniors and a set of large planes for seniors. All other tools, comprising gauges, saws, square, chisels, etc., are for common use. The arrangement shown has the advantage of being readily examined by the instructor before the students are allowed to leave the workshop. A cupboard is provided for storing models or exercises belonging to various sections. A complete list of tools for this cabinet is as follows:—

14 in. tenon saw.
8 in. dovetail saw.
Large trying plane.
Small trying plane.
¼ and ⅜ in. mortise chisels.
1, ¾, ½, ⅜, ¼ in. firmer chisels.
Hammer.
Striking knife.

Large trying plane.
Small trying plane.
Large jack plane.
Small jack plane.
Smoothing plane.
Rasp and file.
Marking gauge.
Mortise gauge.

Cutting gauge.
6 in. try square.
Dividers, 6 in.
Bevel.
12 in. rule.
Mallet.
Screwdriver.


TO BE·EXECUTED
IN PINE·PAINTED
GREEN
15
DECIMETRES·
FEET·
1
2
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6
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10
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3
INCHES·
CENTIMETRES
ELEVATION OF A FITTED TOOL CABINET·
FOR HANDICRAFT AND TECHNICAL CLASSES
SECTIONAL VIEW·
PLAN·SHEWING ARRANGEMENT·
OF·TOOLS IN TOP RACK· · ·

FIG. 2.—Suggestion for tool cabinet accommodating large and small sets of tools for junior and senior students.

The small cabinet illustrated in Fig. 3 indicates a suitable arrangement for a handcraft outfit only, and is intended to be hung on the back of a bench when not in actual use. Upon the commencement of a class these racks are transferred to the students' benches and remain there during the lesson. They may be checked by the instructor after class is finished. A plan shows the arrangement and position of tools allowed to each rack as follows:—

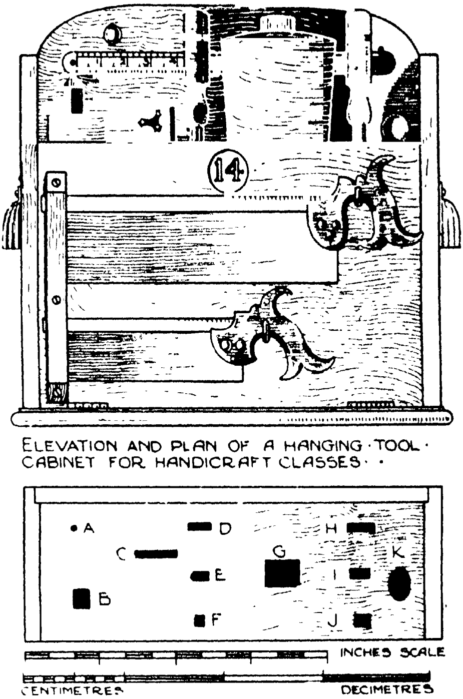

14
ELEVATION AND PLAN OF A HANGING TOOL CABINET FOR HANDICRAFT CLASSES
A
B
C
D
E
F
G
H
I
J
K
INCHES SCALE
CENTIMETRES
DECIMETRES

Fig. 3.—A small tool cabinet for the use of handcraft pupils.

A. marking knife.
B. marking gauge.
C. 6 in. try square.
D. ¾ in. chisel.
E. ½ in. chisel.
F. ¼ in. chisel.
G. mallet.
H. 1 in. chisel.
I. ¾ in chisel.
J. ⅜ in. chisel.
K. hammer.

A small tenon or shoulder saw and a dovetail saw are attached to the front as shown, and a 12 in. iron rule is hung on the back part. All extra tools are stored in the cupboards and are issued as occasion demands. L. in plan of workshop indicates a continuous arrangement of tool cabinets, a decided advantage when sweeping, as no inaccessible corners have to be negotiated.

An **Oilstone Table** (Fig. 4) should be provided, as shown in plan, made about 4 ft. long with the top lined with ⅛ in. zinc. All sharpening by pupils should be effected on this table, which obviates the disposal of oil upon the benches, and also reduces the number of oilstones required. With thirty pupils not more than five oilstones are necessary.

A **Circular Saw** for the instructor or student teacher would be best placed in the timber store, and operated either by foot or a small ½ horse-power motor. It is especially useful in the preparation of material for large classes. A locking arrangement is advisable in order to prevent tampering.

The **Grindstone** (Fig. 5) is the type best suited to handcraft work. The method of operating same will be evident from the illustration. The chisel is secured in a rack or falling frame, and a straight bevel can easily be obtained by a young boy. It also reduces the chance of accident to a minimum.

A **Glue-pot Stand** is shown in plan, consisting of bar iron riveted together with rings at the top. Each ring has a gas tap attached, and a master tap governing all the rings is also fixed above the connexion to gas pipe.

The **Lathe**, illustrated in Fig. 22 (26), is suitable for small work in a handcraft centre for demonstration purposes, and also for the execution of simple turned work. The length is 4 ft., and includes two slide rests and a centre face-plate for flat work. A motor should be attached if turned work is done to any extent.

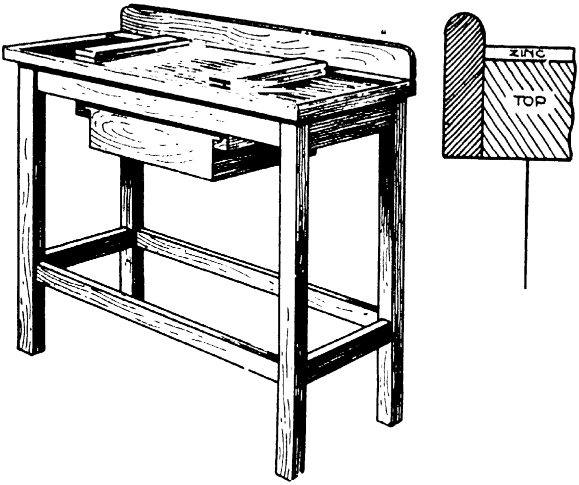


FIG. 4.—An oilstone table with zinc-lined top.

A **Bench** of German manufacture is illustrated in Fig. 6 (1), provided with wooden screws and iron stops. It can also be obtained with iron screws and handles, and these are an advantage in scholastic work, wooden screws being so frequently broken. A double bench is shown in Fig. 7, but its use is not recommended.

TOOLS

PLANES.—Fig. 6 (4) illustrates a **Trying Plane**, used for obtaining perfectly true surfaces, shooting joints, squaring ends upon a shooting board, in fact for practically every planing process that requires great truth and exactness. The length varies from 18-30 in., the former for junior use, and the latter size for special jointing work. Twenty-eight inches is the standard full size for general work. Double irons are used in both sizes—2 in for the small size and 2½ in. for the large one.

Description of Fig. 6 (*continued*).

The **Jack Plane** is illustrated in Fig. 6 (5) It is used for roughly planing material prior to the use of the trying plane. Length varies from 14-20 in. for handcraft and technical work respectively, with irons 2-2⅜ in. wide. Although gauged irons are recommended for all planes, some prefer the ordinary or tapered type.

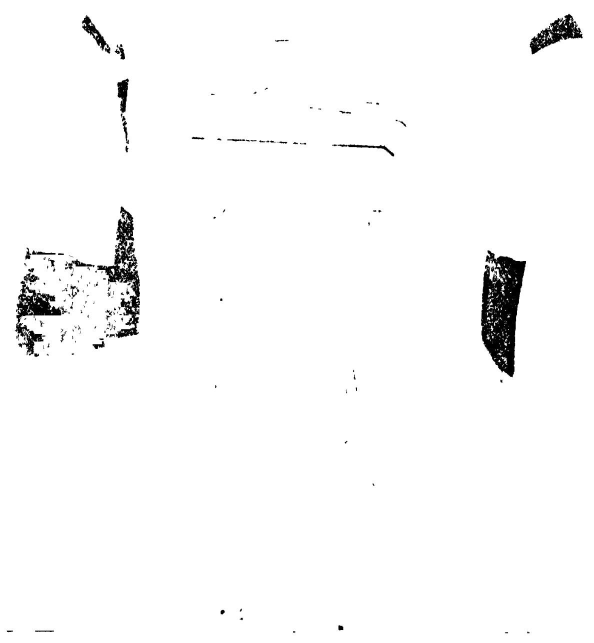


FIG. 5.

A **Smoothing Plane** is shown in (10), and as the name indicates it is used for smoothing up surfaces after they have been prepared with a jack and trying plane. Width of iron varies from 1¾-2¼ in., the smaller size is best suited to handcraft work, the student obtaining more control over a tool proportionate to his size. In all planes the pitch of the iron varies accordingly as it is intended for hard or soft wood, generally speaking, a low-pitched iron is best for young students.

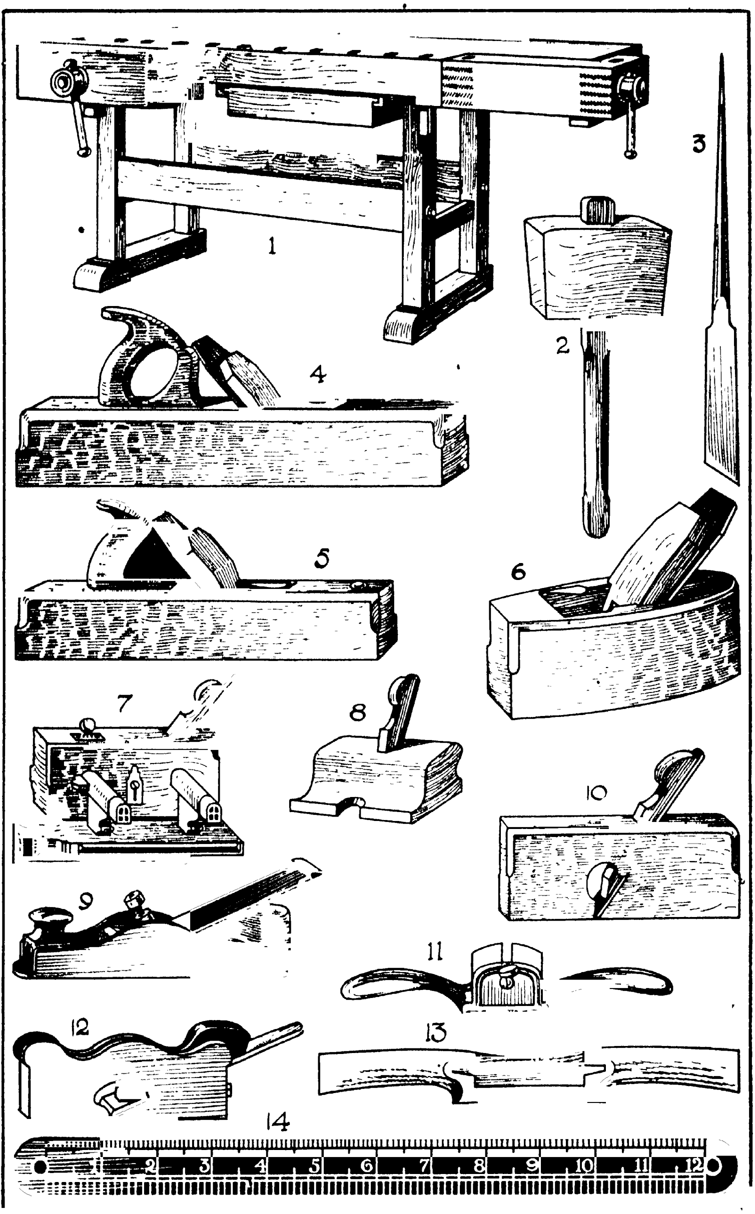


FIG. 6.—Miscellaneous woodworking tools.

Description of Fig. 6 (*continued*).

(7) illustrates the **Plough.** The terms applied to this tool are (1) body or stock; (2) the skate, consisting of a steel fixed in the sole; (3) the fence, which regulates the margin of grooves; and (4) the stop. This is adjustable and is set by means of a screw; it is used to determine the depth of a groove.

(8) is the **Rebate Plane.** Made from $\frac{3}{8}$-1½ in. on sole, and as the name indicates is used for rebating. In addition to its ordinary uses, it may with advantage be used for shooting small veneers when a shoulder plane is inaccessible; it is then worked flat upon a small shooting board.

(9) is the **Block Plane.** Used by craftsmen for shooting end grain of material, general fitting, and mitres. The iron is fixed at a particularly low angle. It is usually used in conjunction with the mitre block (see Fig. 8 (8)).

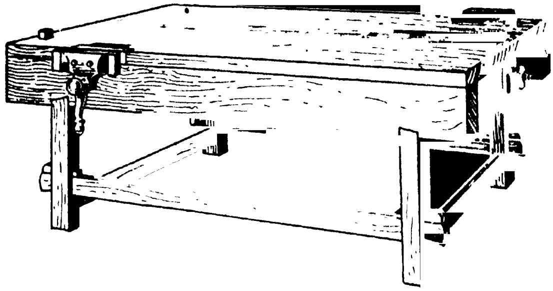


FIG. 7.—A double bench.

(12) is a **Shoulder Plane.** Made of malleable iron, and used for regulating end grain shoulders. This tool is almost indispensable when working veneers. It is then used on its side, and in conjunction with a shooting board. The cutting-iron is fixed at a low angle, and, as is also the case with the block plane, the bevel of the iron is placed uppermost.

An **Old Woman's Tooth** is illustrated in (8), consisting of a block of wood with a plough-iron wedged in position, the cutting part projecting beyond the sole, and used chiefly for regulating the depth of grooves cut across the grain, after the end has been roughly removed with a chisel.

An **Iron Spokeshave** is shown in (11). Useful for fine work, especially in hardwood. The English pattern spokeshave, see Fig. 6 (13), is made flat or curved in section, as is also the American pattern, suited respectively for concave and convex edges or surfaces. The English types are made in box, lance, and beech wood.

(14) illustrates an **Iron Rule.** Such rules may be obtained up to 3 ft. long divided with English and metric measures.

(2) illustrates a beechwood **Mallet,** made in various sizes, and (3) is a combined marking and striking knife made of hard steel.

SAWS are divided into a number of classes according to their design and system of teeth (Fig. 8).

A **Hand Saw** is illustrated in Fig. 8 (9). The rip saw of similar shape is properly called a **Half-rip Saw,** length 28 in., teeth spaced ¼ in. apart, and is used for heavy cutting or "ripping" up stuff. The **Hand Saw** ranges from 20-26 in. in length, the blade of steel, teeth 6½ to the in. and ⅛ in. deep

Panel Saws are rather smaller in size and the teeth are also closer together. The length ranges from 16-26 in. They are especially suitable for young handcraft students for cross cutting and general use The American Disston saws are of specially good quality, and their being made with a blade slightly tapering in cross-section, reduces the necessity for much "set" upon the teeth.

A **Tenon Saw** is illustrated in (7). Made with iron or brass backs, according to quality. The thickness of the blades and the spacing of the teeth vary. The blade is held tightly by the metal back, and, as also with dovetail saws, the process of fixing them is as follows: The back is bent slightly in its length and is then closed over the handle end of the blade. The remainder of the blade is then pressed into position, and the back is then sprung straight and closed over the steel. The natural tendency for the back to spring back into a curved shape holds the blade rigid and in constant tension. The use of this saw is restricted to light cross cutting and for wide shoulders. It is not used for tenons as the name seems to imply. Disston shoulder saws range from 12-18 in., and are excellent substitutes for the former in educational work, the teeth are smaller and they are not unwieldy.

A **Dovetail Saw** is similar in shape to the tenon saw, but with an open handle. Lengths vary from 6-10 in. with teeth spaced 15 per inch. They are used for cutting dovetails, small tenon cutting, and cross-grained grooves.

(2) shows a **Bow Saw,** so named because of its construction with bow-string tension attachment. The frames are made of beech or box wood with separate handles, and the blades range in length from 8-16 in., teeth spaced approximately 12 to the inch, width of blade about ¼ in. They are used for general curved cutting, such as circles or shaped brackets.

(4) is sometimes called a **Compass Saw.** It is however generally known as a **Keyhole Saw** from its particular use. It is only used for cutting away material inaccessible to the bow saw.

(1) shows a small frame or **Fret Saw**; the best pattern for cutting thin metals, mother of pearl, veneers, or fretwood, and thin material generally. Fret saws are used with the frame, to be obtained in packets of one dozen in varying degrees of fineness. If a saw breaks off, the thumbscrew can be slackened and the opening of the frame contracted, when a broken saw can be fastened in again.

Description of Fig. 8 (*continued*).

(3) illustrates one type of **Mitre Cut.** Used when cutting butt or mitre joints in mouldings, etc. It is of beech and can be made as a class model.

(5) shows an **Adjustable Bevel.** Used for setting out oblique shoulders and angles and testing bevelled edges. The stocks are made of rosewood and ebony with a dotted adjustable steel blade.

(6) shows a **Hand Drill** for boring hard woods and thin metals. Drills may be obtained with a screw attachment in the handle, which when screwed off discloses a small receptable used for storing the drills. This instrument is especially useful for boring simple patterns in wood for inlaying in wax or other material.

A **Mitre Block** is shown in (8) with a piece of moulding in position ready for planing. The metal screw action illustrated is much better and quicker to operate than the wooden screw type. These mitre blocks are prepared to shoot wood at angles of 90°, 45°, and 77½°, square or butt, mitre and half mitres respectively.

A **Block Plane** (12) Is designed specially for use with the latter

Oilstones (10) of various varieties are as follows. (1) Washita, a good stone for general use. The cutting qualities vary, and can be judged best by rubbing the thumb-nail along the surface, comparing the relative grip with stones of differing quality. (2) Indian oilstones are rather more expensive than washita. They are excellent cutting stones, rapid sharpeners, and impart a keen edge. (3) Charnley Forest, a close-grained stone. (4) Turkey oilstones, excellent cutters, lasting, and sharpeners, rather more expensive than the above varieties. (5) "Arkansas" an expensive kind, excellent for surgeons' and dentists' instruments and other fine tools. It is composed of pure silica, crystallized similarly to the washita stone, has a perfectly smooth surface, and yields only to the cutting of a diamond when being trued up, this stone is very expensive.

Slips (13), may be obtained of various sections. Suitable for sharpening gouges and shaped plane-irons in any of the preceding kind of oilstones

Pincers (14), do not demand a detailed explanation here, being a tool familiar to all.

(15) shows a **Twist Gimlet.** Used for boring holes to receive screws.

(11), a **London pattern Hammer.**

(12), a **Set Mitre** for setting out mitred work.

(17), a **Bradawl,** which when being used should have the cutting edge of the blade placed across the grain, thus avoiding the splitting of the wood fibres.

(18), a **Screwdriver.**

Fig. 8 (19, 20), a **Rasp** and **File** respectively for wood To be obtained in varying degrees of coarseness. The latter cut specially for use with wood.

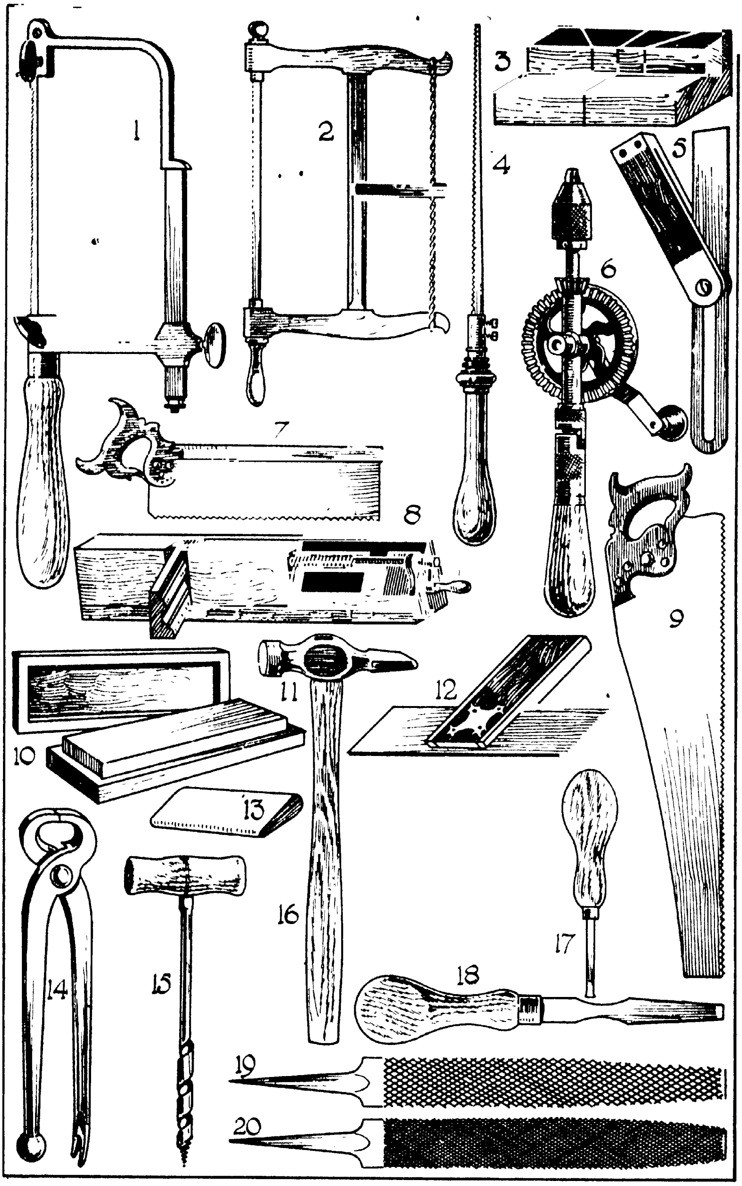


FIG. 8.—Saws and various other woodworking tools.

CHISELS AND GOUGES.—The **Firmer Chisel**, see Fig. 9 (2), is so-called because it is the firmest type of paring chisel. Firmer chisels are made from 1/16-1½ in. wide of well-tempered steel, and used for general chisel work where striking with a hammer or mallet is not necessary. A **Paring Chisel** is shown in (1), the blade of extra length, and used for work inaccessible to a firmer chisel. The width of blade varies from ¾-1½ in. All chisels are made with either square or bevelled edges; the latter, see (3), afford an advantage in dovetailing and in bevelled work where a square chisel edge could not be entered in the corner (4) shows another kind of handle, made chiefly in boxwood. Fig. 10 (1) illustrates a **Firmer Gouge**, made from ¼-1½ in. in width and of varying curvature. Firmer gouges are always ground and sharpened on the outside face, distinguishing them from scribing gouges—which are sharpened upon the inside—thus enabling a cut to be made square with the face of an object or moulding. Firmer gouges are especially useful for recessing work—such as the concave shape in a pen tray, etc. Carving gouges are made of hard-tempered steel, much thinner in section, with the bevel hardly perceptible, and are made in various shapes.

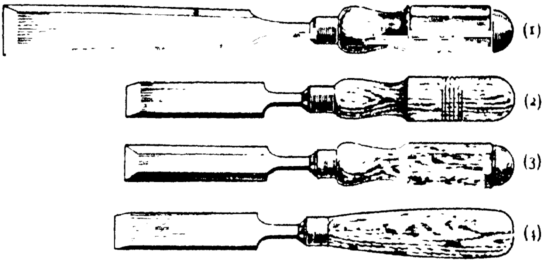


FIG. 9.—Various types of chisels and handles.

Mortise Chisels are illustrated in Fig. 10 (2); sizes range upwards from ⅛ in. in sixteenths. Their use is restricted to mortising, i.e. the act of preparing the receptacle or cavity to receive a tenon or mortise lock.

BORING TOOLS.—Fig. 10 (7) illustrates a **Brace** with a ratchet attachment which permits the use of this tool in a corner, where an ordinary brace could not be used. The best types are made with ball-bearing head (see diagram adjoining) and mounted with cocos or ebony wood.

Dowel or Twist Bits are illustrated in (4); sizes range from 1/16-1 in. in diameter. They are used for deep boring where a centre bit would "drift" if bored to any depth.

The Spoon Bit (3) is used for boring wood to receive screws and effect a clean hole, reducing the possibility of splitting to a minimum.

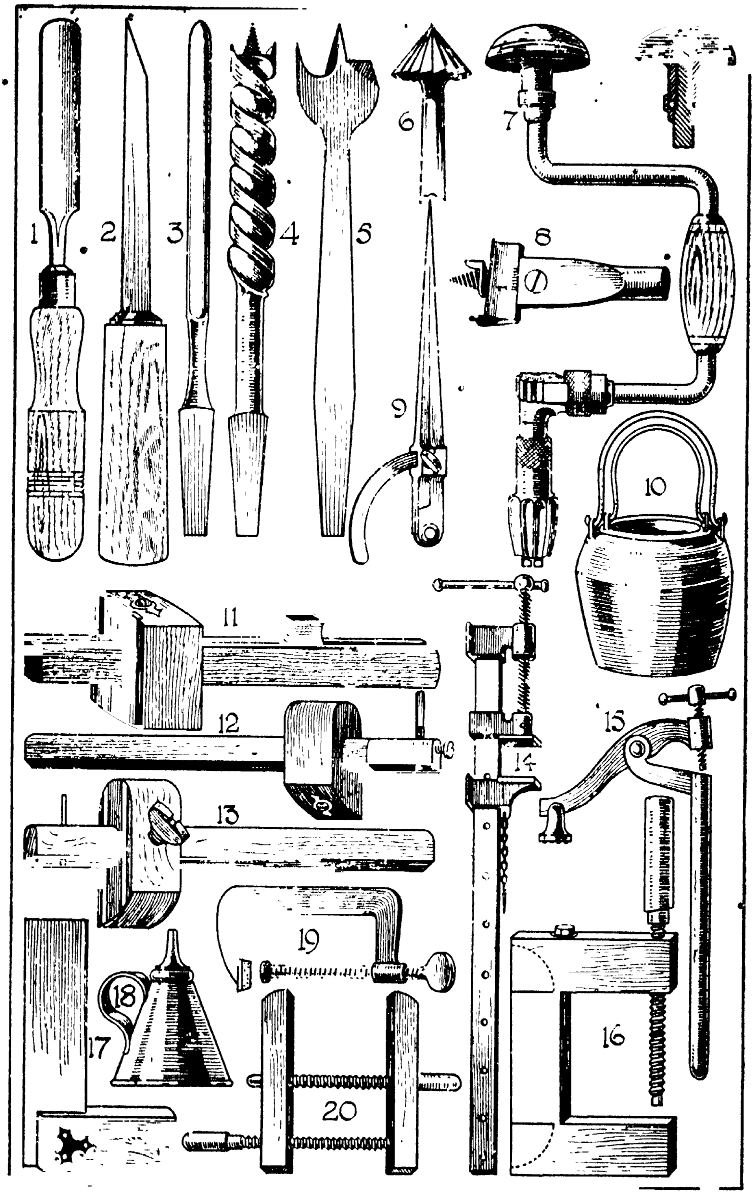


FIG. 10.—Woodworking tools.

Description of Fig. 10 (*continued*).

Centre Bits (5), are used chiefly for comparatively shallow boring, and the larger sizes are of special utility, as for example, when boring out the core of an oilstone case is necessary.

(6) is a **Rose-head Countersink.**—Used to shape the heads of holes to receive screws. This type bores much cleaner than the **Snail-head Countersink,** which is a quick cutter and useful for large work.

GAUGES.—The **Mortise Gauge** (11), is made in several qualities and styles of finish, chiefly in rosewood or ebony with brass fittings. The type illustrated is most serviceable, and does not require the use of a screwdriver when the points have to be adjusted. This is the best type owing to its simple action.

(12) is a **Cutting Gauge** with brass-cased head and screw adjustment. This tool is used for splitting thin material, and may be used to advantage in almost every instance where gauging is necessary—making a thinner and cleaner line than the marking gauge. All gauge heads are better when faced up with brass, lasting longer, but working rather heavier owing to the extra grip of the metal-facing.

A **Marking Gauge** is shown in (13). Used for gauging up material previous to planing, and also for the production of lines parallel to an edge from which the gauge is operated. The marking point consists of a small round piece of steel filed to a sharp point. Brass strips are sometimes cut into the face of the stock (see illustration) and add to its wearing qualities. Other gauges of a special character are described in the succeeding chapters.

(9) illustrates a pair of **Steel Compasses** used for marking circular arcs, etc., upon wood. An alternate pattern, which permits of a more speedy adjustment, is called **Spring Dividers.** In addition to their use in striking arcs, the latter pattern are specially suited to the divisions of lines by trial.

Cramps.—(14) illustrates an iron type which has obvious advantages over the wooden pattern. They are stronger and truer, easier to adjust, and do not necessitate the frequent renewal of the screws. They are used for cramping up joints and framing, and are made up to 6 ft. long. Lengthening bars can also be obtained to extend the action of the cramp.

(19) is a **Gee Cramp** for small work—fixing mouldings and slips in drawers.

(20) illustrates the **English pattern Handscrew,** usually made with beechwood chops and split English ash handles. Split material for the screws is essential, or frequent breaking is bound to occur. Hickory, being close-grained, strong, and easy running, is a superior wood for these screws and chops.

The **German pattern** is illustrated in (16), made of hornbeam. A strong handscrew, and more popular with most craftsmen than the English type. Sizes of both vary from 4 in. chops.

A **Glue-pot** is shown in (10). The example is of iron with galvanized lining. Copper glue-pots, although more expensive, are better because of the

Description of Fig. 10 (*continued*).

quicker heating qualities and freedom from breakage to which the cast-iron type is particularly susceptible.

A **Holdfast** is illustrated in Fig. 10 (15), and is used to secure boards and general work to the bench.

(18) is a suitable kind of **Oil-can,** and that most important tool, the **Try Square,** used for a very large number of purposes, is shown in Fig. 10 (17).

The **Straightedge,** of which several are necessary in the general equipment of a well-ordered handcraft shop, is illustrated in Fig. 11. They are best made of mahogany with rosewood or satinwood or ebony edging; length varying from 2-5 ft. 6 in.

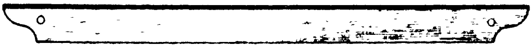


FIG. 11.—Straightedge.

Winding Strips are shown in Fig. 12. Made from mahogany with ivory or ivorine sights. Short dowels are fixed as shown to keep a pair together when not in use.

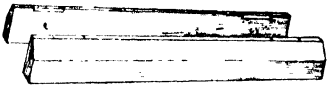


FIG. 12.—Winding strips.

A large **Wooden Square** is shown in Fig. 13. One of this type should be included in general equipment. Length of stock and blade varies; the latter ranges from 10-24 in. in length.

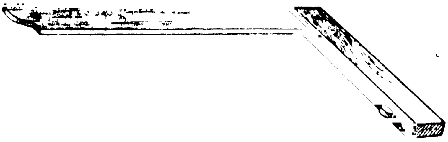


FIG 13.—Large wooden square.

A **Shooting Board** is illustrated in Fig. 14. It is best made in mahogany. A mitre attachment is dowelled to the board, this being used for shooting mitre in clamps, flat mouldings, etc. It can be removed at will.

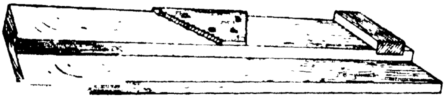


FIG. 14.—Shooting board.

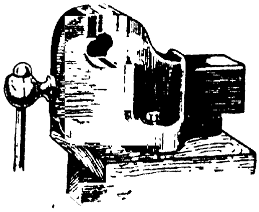


FIG. 15.—A horizontal vice.

Fig. 15 is a horizontal vice, one of which should be in every equipment. It is invaluable for holding metal or tools whilst cutting or repairing.

METALWORKING TOOLS AND THEIR USES (Fig. 16).

The tools illustrated in Fig. 16 are as follows :—

(1) **Centre Punch.**—Sometimes called a mitre punch. Used for marking work of all descriptions, also for dotting the place where holes have to be drilled for the centre of the drill to start in. Made of tool steel.

(2) The **Engineer's Hammer** head consists of three parts—the face, the eye, and the pane, pene, or peen. The shaft should be of hickory or ash, and fastened with a metal wedge driven in parallel with the length of the head. The shaft should be carefully fitted so that the oval of the shaft is true with the head; if it is otherwise it causes the student when using a chisel to miss the head of the chisel and hit his hand.

(3) **Scriber.**—Made either of brass or steel—brass for use on iron and steel, steel for use on brass, copper, etc. Used for marking in.

(4) **Outside Calipers.**—Used for measuring the outside diameters of bodies and for transferring sizes from the rule to articles in the round, or vice versa. Usually made of iron or steel and used largely in turning. There are many varities.

(5) **Wing Compasses.**—Made of iron with hardened steel points. Used for geometrical setting out of all kinds.

(6) **Scratch Card** or **Card Wire Brush.**—Used for cleaning files by brushing it on the file and in the same direction as the cut of the teeth. It consists of card wire tacked on a piece of wood shaped so that it is suitable for holding in the hand.

(7) **An 8 in. Hand Bastard File.**—Used for filing all kinds of flat surfaces and roughing down any metal. Sometimes called a safe edge flat file, as it has one edge without teeth, for use when filing shoulders.

(8) **An 8 in. Half-round Bastard File.**—Used for the preliminary roughing down of flat and curved surfaces for any metal.

(9) **Hand** or **Cold Chisel.**—Used for cutting all kinds of metals in a cold state in contradistinction to a hot hand chisel that is used for cutting metals in a hot state. For this purpose it would be 3 in. longer and thinner at cutting edge. Made of tool steel.

(10) **Soldering Iron.**—Or sometimes called a copper bit. Used for all kinds of soft soldering. Handle usually of wood, rein of wrought iron, bit of wrought copper. Made in various sizes and shapes; 1-2½ lb. are the most useful weights.

(11) **Tinman's Gas Stove.**—Used by a tinman when soft soldering, so that one iron can be getting hot while the other is being used. Stove made of cast iron.

(12) **Lancashire Hack Saw.**—Used only for soft metals, such as brass, copper, etc. Frame of wrought iron, blade 12 in. long, and thick on edge where teeth are, thin at the back, tempered so that it can be filed; no set to

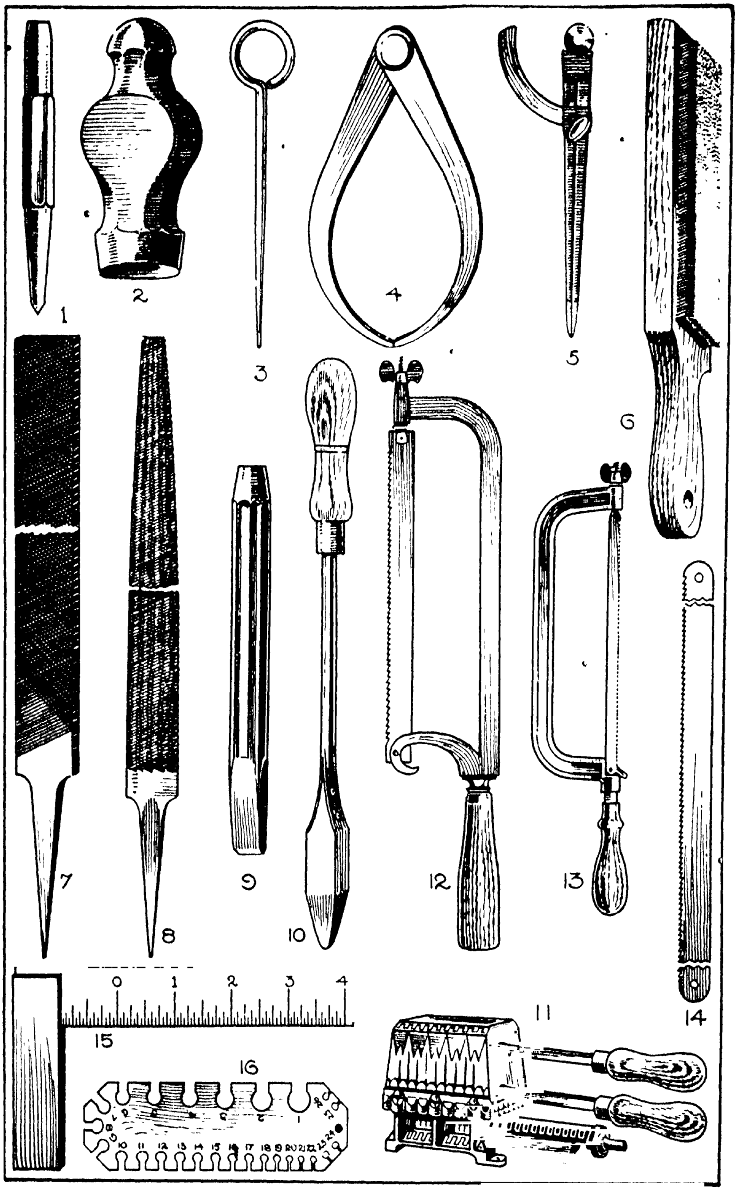


Fig. 16.—Metalworker's tools.

Description of Fig. 16 (*continued*)..

teeth. Should not be used for steel or iron. Teeth 8 or 10 to the inch. Should be held as shown in Fig. 17.

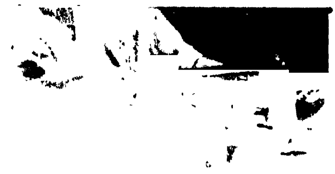


FIG. 17.—Method of holding a hack saw.

(13) **Star Hack Saw.**—Used for steel and iron as well as other metals. Frame of cast-iron, blades 8 in. long, hardened, cannot be filed. Teeth 14 to the inch. Can also be had with twenty-three teeth per in.

(14) **Hack Saw Blade.**—Measurements taken over all. Sometimes tempered so that they can be filed, or hardened so that they cannot be filed, or hard teeth with soft backs.

(15) **Steel Try Square.**—Made of all iron or steel, sometimes with or without measurements, hardened or soft.

(16) **Imperial Standard Wire Gauge.**—One of the gauges used in measuring the various thicknesses of metal. Made of steel and hardened and tempered. Not used for steel wire, lead, zinc, silver, or gold.

The tools illustrated on Fig. 18 are as follows:—

(1) **Double-handed Tap Wrench.**—Used generally for turning a tap. Holes made to suit various sized tap heads. Made of iron or steel.

(2) **Adjustable Tap Wrench.**—Used for the same purposes as No. 1, with the exception that adjustment is obtained by turning the right-hand handle which has a hole for a lever to assist in tightening.

(3) **Single-ended Spanner.**—Used for turning bolts and nuts. Made of malleable iron with case-hardened jaws.

(4) **Double-ended Spanner.**—Used for the same purpose as No. 3.

(5) **Stillson Wrench.**—Really an adjustable spanner with teeth; the more pressure put on the handle the tighter the grip in the jaws. The teeth are in opposite directions, and they mark the object being held.

(6) **Double-action Coach Wrench.**—Also an adjustable spanner, but the jaws open and close very quickly, owing to the two screws which are right and left handed; also a better grip of the object being held in the jaws can be obtained. Sometimes called a monkey wrench.

(7) **Stocks and Dies.**—The stock is that portion with handles which holds the dies. The dies are adjustable by means of the set screw, and a number of sets of dies are usually supplied with the stocks. These are used for outside screwing of all sorts up to the capacity of the stocks.

(8) **Stocks and Dies.**—Sometimes called fine dies for brass, as they are usually used for screwing brass and copper tube, and the thread is twenty-six to the inch. This thread is used largely in brass work. The dies are for three different sizes and denote the outside diameter of finished work. There is also a wheel for cutting off thin tube, which, like the dies, is adjustable by means of a thumbscrew.

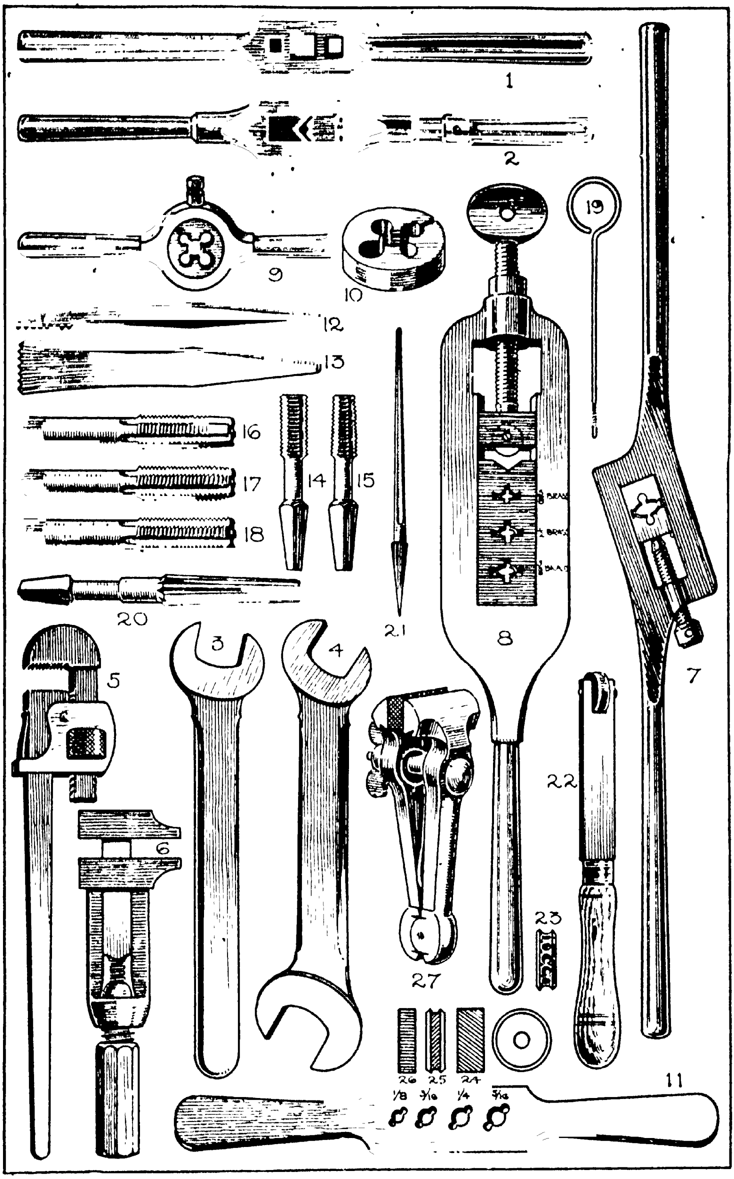


FIG. 18.—Metalworker's tools.

Description of Fig. 18 (*continued*).

(9) **Stocks and Dies.**—Sometimes called B.A. stocks and dies (B.A. means British Association). Stocks are usually of gunmetal, and the die is in one piece. A saw-cut is put in one side of die and a small set screw to allow a small adjustment by means of the springiness of the die to compensate for wear. The dies are held in their place by means of the milled-headed set screw shown, and sizes are known by number from 0 to 10, 0 being the largest. This is the B.A. standard.

(10) **Circular Split Die.**—This is the die used in the stocks of No. 9.

(11) **Double-handed Screw Plate.**—A piece of flat steel, pierced, tapped, hardened, and tempered, for screwing pins by once running down. Made largely to suit Whitworth standardized threads.

(12) **Inside Chaser.**—Sometimes called inside screwing tool, or inside comb chaser. Made in all pitches for screwing internal vee threads; it has to be fixed into a handle and used by hand.

(13) **Outside Chaser.**—Used for cutting external threads of all kinds and sizes. Makes a pair with (12).

(14) **Plug** or **Bottoming Tap.**—The one illustrated is a ⅜ in. fine thread, that is twenty-six to the inch.

(15) **Taper Tap.**—Makes a pair with (14), and this pair with the remaining ones for ½ in. and ⅝ in. would make a set with the stocks and dies (8).

(16) **First Taper Tap.**

(17) **Second Taper Tap.**

(18) **Plug** or **Bottoming Tap.**—These three form a set of taps and are of one size and pitch. Used in combination with the stocks and dies (7).

(19) A **Wire Tap.**—Made only in small sizes; it does away with the necessity for using a tap wrench.

(20) A **Reamer** or **Rimer.**—Made in all sizes, and used for enlarging holes. The ends are made tapered and squared so that they can be turned by means of a tap wrench or used in a fitter's brace, illustrated in Fig. 20 (9).

(21) **Broach.**—Has five flat sides. Used for enlarging holes.

(22) **Milling Tool.**—Sometimes called knurling tool, consisting of a knurling wheel which runs on a hardened pin in an iron holder. Used by pressing against the work, which is revolved in lathe, when the knurling wheel cuts a pattern on the work.

(23) A **Pearling Wheel.**—Used in the same manner as a knurling wheel, but mostly used to decorate, or put a series of pearls or beads on a circular object.

(24, 25, 26) **Knurling Wheels.**—Used in the holder (22). Made of steel and hardened.

(27) **Lancashire Hand Vice.**—Used for holding work in the hand or for holding templets to metal while the metal is being marked out. Sometimes made of all steel or of wrought iron with jaws faced with steel.

SMITH'S TOOLS.—The tools illustrated in Fig. 19 are some of those that are used in the forging of metals.

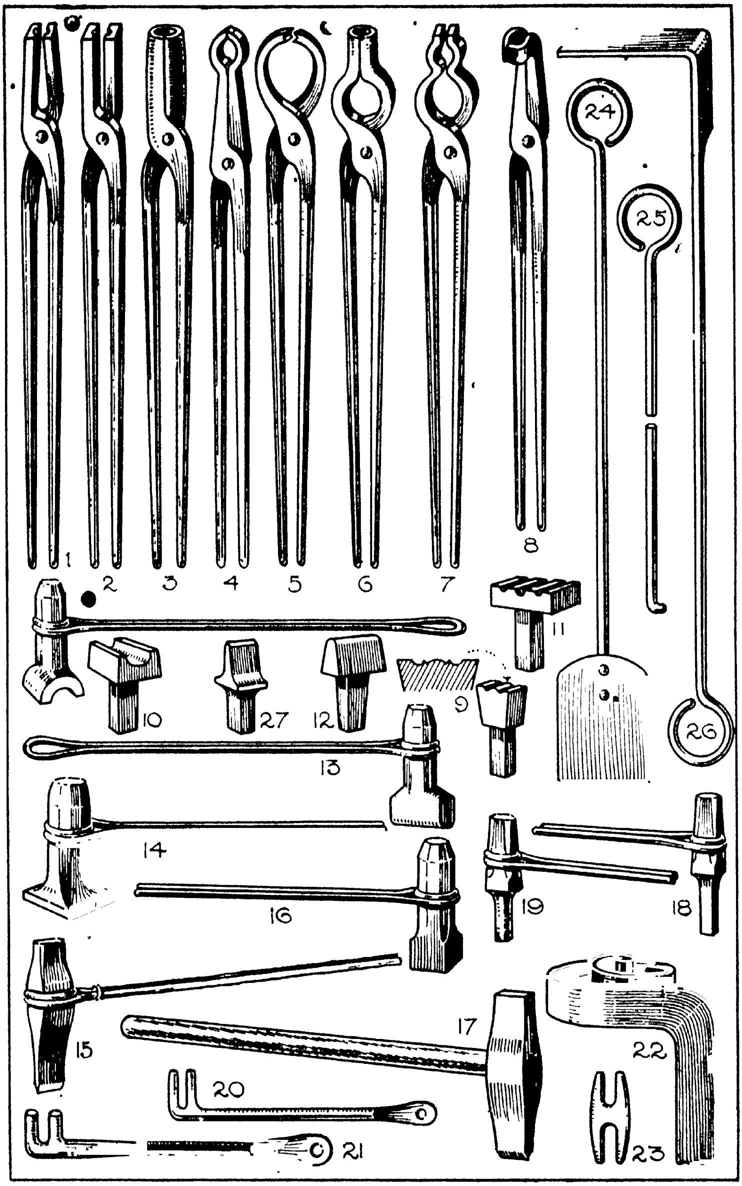


FIG. 19.—Smith's tools.

Description of Fig. 19 (*continued*).

The first few numbers show some of the tongs in general use, but there is a large number of different shapes which are generally made to fit the work in hand or are altered to fit, as unless the tongs fit the work so that it is held securely, and in the proper manner, an accident is likely to occur. Forge tongs are made of wrought iron and of all sizes.

(1) **Open-mouthed Tongs.**—Used for holding medium-sized pieces of round or square iron. Sometimes called flat bills.

(2) **Close-mouthed Tongs.**—Used for holding small sizes of round or square iron. Sometimes called flat bills.

(3) **Hollow-bit Tongs.**—Used for holding round iron. Sometimes called round bits.

(4) **Rivet Tongs.**—Used for holding rivets or small round iron at right angles to tongs. Sometimes called ring tongs.

(5) **Bolt Tongs.**—For holding bolts or similar work. The hollow at back of jaw allows the head to clear the tongs. Also used for holding flat iron to bend it edgewise.

(6) **Bolt Tongs.**—Another form of (5).

(7) **Pick-up Tongs.**—For picking up work of irregular shape. Sometimes called mandrel tongs.

(8) **Bent-bit Tongs.**—For holding iron parallel to tongs. Sometimes called side tongs.

Tongs for holding flat iron are shown in Fig. 20 (8).

(9) **Bottom Tool.**—For making mouldings. The iron, a little smaller than the width of the tool, is heated and placed in position and is driven into the tool by means of a flatter and sledge hammer.

(10) **Bottom Swage** or **Rounding Tool.** - Corresponds with the rodded top swage shown just above it. Used for making anything round, and they are made in various sizes.

(11) **Bottom Swage.**—Of three different sizes, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$ in.; for rounding up small tenons or similar work.

(12) **Bottom Fuller.**—Used in conjunction with (13) for putting hollows or necks in the work.

(13) **Top Fuller.**—Used in conjunction with (12) as above.

(14) A **Flatter.**—Used for bringing work to a smooth flat surface.

(15) **Hot Sett.**—Used for cutting hot metal. It is much thinner than a cold sett and not tempered so hard, and has a sharper angle for cutting edge.

(16) A **Set Hammer.**—Used for setting down square shoulders or similar work.

(17) A **Cold Sett.**—Used for cutting cold metal. Is much thicker than a hot sett and tempered to a dark brown colour, and cutting angle is 60°. Usually fitted with a withy twisted round chisel as shown in Ch. XIV, Fig. 5 (10), or has a hazel rod fitted into the eye as shown.

(18) A **Square Drift Punch.**—Used for punching square holes.

Description of Fig. 19 (*continued*).

(19) **Round Drift Punch.**—Used for punching round holes.

(20 and 21) **Scroll Wrenches.**—Used for bending metal into different forms; (20) is forged out of one piece of metal, and in (21) the fork is forged from one piece, and a handle made from a piece of gas barrel is shrunk on.

(22) **Scroll Iron.**—When doing a number of pieces which are all the same shape it is quicker to make a scroll iron and bend all the scrolls on it by holding the end of the iron at the centre and pulling it round (usually when the iron is at a red heat), thus making them all alike.

(23) **Scroll Horn** or **Fork.**—It is put in the vice and used in conjunction with (20 and 21).

(24) **Smith's Shovel** or **Slice.**—For use at the forge fire.

(25) **Poker.**—Used at the smith's fire. The end is turned up so that the clinker which forms at the bottom of the fire can be picked out.

(26) **Smith's Rake.**—Used for pulling the fuel over the work in the fire, etc.

(27) **Hardie** or **Anvil Cutter.**—Used for cutting off pieces of bar or rod iron either hot or cold. The hardie fits into the square hole in the tail of the anvil. The iron is laid across the edge of the hardie and the **iron** is struck with the hand hammer. The iron is then reversed and process repeated, a slight tap and the iron breaks off.

The illustrations in Fig. 20 are of the plant and tools largely used by the smith:—

(1) **Portable Forge,** fitted with a hood, and has a solid tue iron or tuyere of cast iron. The other part of the forge is of wrought iron riveted together. Forges are made in various sizes, and the sizes are those of the bed or hearth, and the one illustrated is 33 × 27 in. The hearth should be about 2 ft. 3 in. from the floor.

(2) **Double-blast Circular Bellows,** made in various sizes. The nozzle is connected to the bellows by means of a piece of leather tubing. If the bellows are at a little distance from the forge, the blast is conducted to the back of the tue iron by means of large-bore gas barrel. The size is the diameter.

(3) **Grindstone.**—The size of this is known by the diameter and width of the face of the stone. The one illustrated is 36 × 5 in. The stone itself is either of natural sandstone, or of some artificial composition. They are of different degrees of coarseness and hardness, and some of the names are as follows: Yorkshire, Newcastle Blue, Bilston. The stone should not rest in water for any length of time as this tends to soften it and so make it wear unevenly.

(4) **Hand-drilling Machine,** one of the simplest forms. Made mostly of cast iron, except the spindles, which are of wrought iron. The drill is fed downwards by means of the hand wheel on top, and holes up to 1 in. diameter can be easily drilled with it.

(5) **Smith's Anvil and Stand.**—The anvil is of wrought iron faced with steel. The parts are as follows: The horn or beak; the chopping step or block or table,

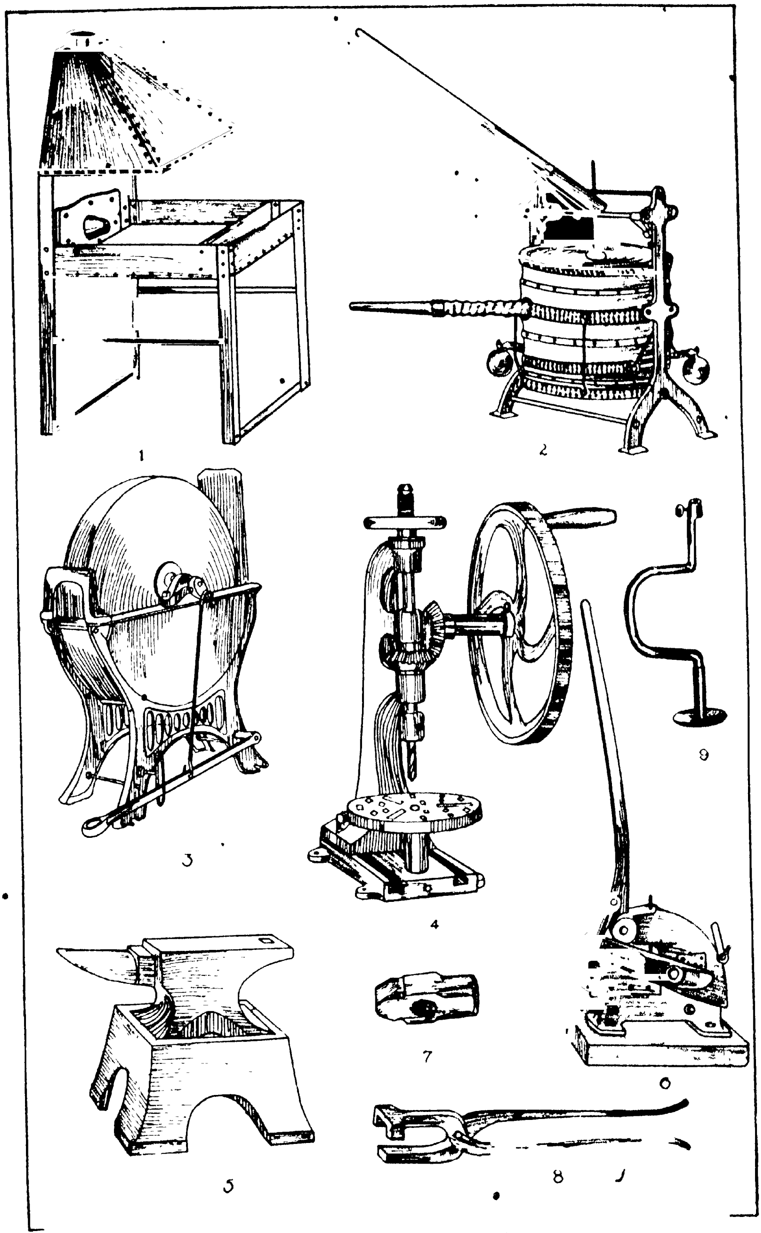


FIG. 20.—Smith's plant and tools.

Description of Fig. 20 (*continued*).
which is left soft for cutting on; the face, which is hardened and slightly rounded; the tail, which has a square and a round hole in it and is flat. The square hole is for bottom tools, and the round hole is for use when punching small holes. Underneath the tail there is usually a hole which is for placing a lever in, to assist in lifting the anvil. The stand is of cast iron. A tree trunk half-buried in the ground makes a good stand, as it absorbs vibration and does not jump like the cast-iron stands.

(6) **Lever Shearing Machine** for cutting thick sheets and bar iron. That portion which shears the rods is called the cropper.

(7) **Straight Pane Sledge Hammer.**—A useful weight is about 8 lb.

(8) **Box Tongs** for holding flat iron rod.

(9) **Fitter's** or **Metalworker's Brace.**—It has a taper square hole for the drills and they are fixed with a thumbscrew.

The tools in Fig. 21 are mostly sheet metalworker's tools and are as follows:—

(1) **Two-hole Gas Pliers.**—They are measured over all and the length should be stated, such as 10 in. two-hole gas pliers. Their uses are varied. The 5 in. size are called burner pliers.

(2) **Bellhanger's Cutting Pliers,** or **Flat-nosed Cutting Pliers.**—Known also by their length over all. Made from 5-10 in. long.

(3) **Round-nosed Pliers.**—Made from 5-10 in. long.

(4) **Manchester Cutting Nippers.**—Made from 6-18 in. long.

(5) **Tinman's Straight Shears** or **Snips.**—Made also with curved jaws, are then known as bent snips. Made from 6-16 in. long.

(6) **Fret-saw Frame,** best quality. Made of tool steel, used by piercers; measured from saw blade to back of frame. Usual size 12 in.

(7) **Cross-pane Riveting Hammer.**—Head weighs from about 4 oz. to 2 lb. A heavier make of head is called an engineer's or fitter's cross-pane hammer, and weighs up to about 3 lb.

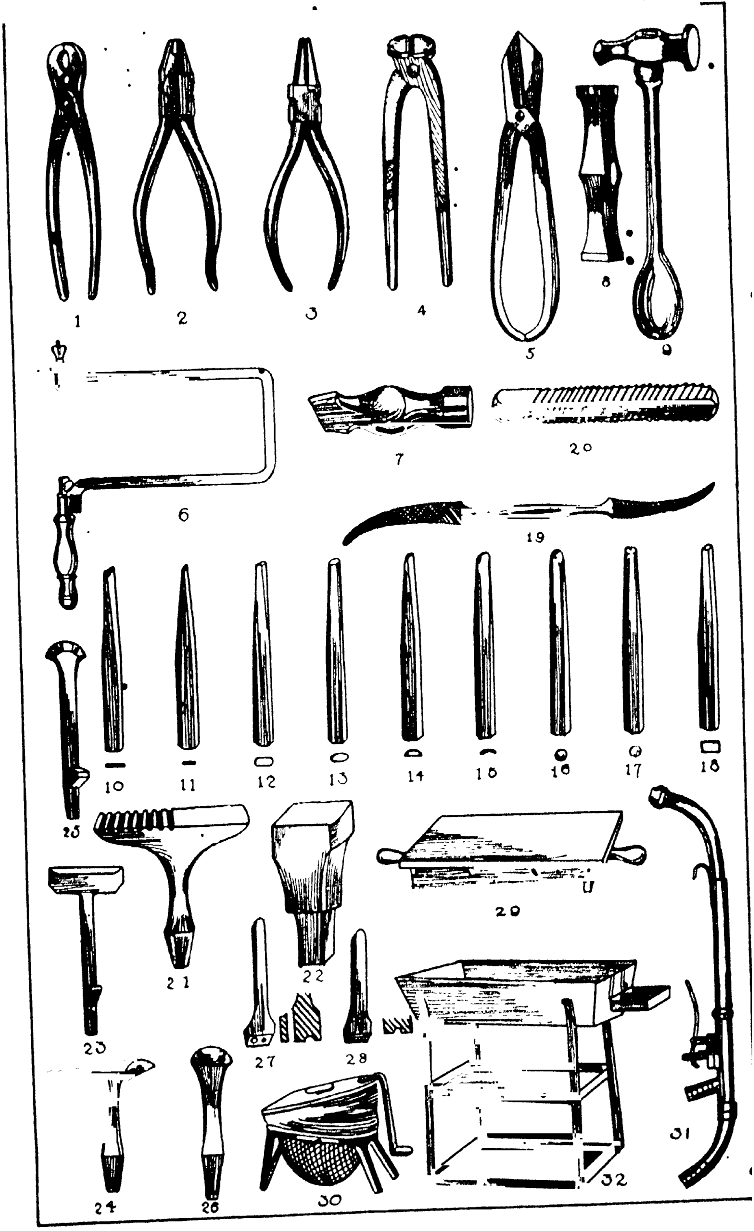
(8) **Round and Square-faced Planishing Hammer.**—Sometimes called a smoothing hammer. Used for smoothing or flattening sheet metal. Made in all weights up to 4 lb.

(9) **Chaser's Hammer** or **Repoussé Hammer.**—Used chiefly by chasers and embossers. Weight of head from 2-4 oz.

(10-19) **Chasing Tools** or **Repoussé Punches,** and numbers (10-11) are **Liners** or **Tracers**; (12-13) are **Raising** or **Cushion Tools**; (14) is a **Setting-down Tool,** as the straight side is higher than the round; (15) is a **Half-round** or **Curved Tracer**; (16) is a **Cup** or **Ring Tool**; (17) is a **Pearling** or **Ball Tool**; (18) is a **Flatter** or **Facing Tool** or **Planisher**; (19) is a **Riffler** or **Riffle,** used for filing the hollows and shaped surfaces in modelled and cast work.

(20) **Drift,** used for finishing a square hole to an accurate size.

(21) **Creasing Iron.**—Used for knocking up and finishing beads, wired edges, etc.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Description of Fig. 21 (*continued*).

(22) **Tinman's Anvil.**—One edge is rounded off and one side is curved, but the curved edge is square. Made of wrought iron and faced with steel, hardened and polished. Must be kept polished and covered up.

(23) **Hatchet Stake.**—The edge is of steel hardened and polished.

(24) **Funnel Stake.**—Made of wrought iron and polished, not steel faced.

(25) **Half-moon Edging Stake.**—Faced with steel, hardened and polished.

(26) **Pepper-box Head-stake** or **Ball Head-stake.**—Faced with steel and hardened and polished.

Note.—Nos. (21-26) must be kept polished and well looked after, as any marks on these stakes are transferred to the metal. This also applies to Nos. (8) and (29). These are made in many sizes and weights, and are usually sold by the pound.

(27) **Rivet Set.**—Used for setting down the metal after the rivet has been placed in position. At the side of the hole there is a hollow cup for rounding up the tail of the rivet after it has been hammered over.

(28) **Groover** or **Seam Set** for setting down seams or folds in sheet metal.

(29) **An Engineer's Surface Plate.**—Used for testing and setting out. Must be kept covered. Usually of cast iron and planed up in a planing machine. Only the most expensive ones are hand scraped. Made in various sizes.

(30) **Fletcher Russell Foot-bellows** for blowpipe work; very useful for small work and does not take up much room. Made in different sizes.

(31) **Gas Blowpipe.**—Used for brazing and silver-soldering and connected with the foot-bellows (30) by india-rubber tube. Known by the size of the outside tube it is made of. The one illustrated is a ¾ in. blowpipe with lever-valve gas control.

(32) **Brazing Pan.**—Made of sheet and bar iron riveted together. Filled with coke, fireclay, asbestos, charcoal, or pumice stone, and used for brazing, silver-soldering, etc. A handy size is one about 18 × 24 in. and about 2 ft. 6 in. high to the top edge. The small trays at the side are for spelter and borax.

The tools illustrated in Fig. 22 are mostly lathe tools as follows:—

(1) **Straight-fluted Drill** with parallel shank.

(2) **Morse-twist Drill** with parallel shank.

(3) **Rose Countersink** with taper square shank. This is only suitable for soft metals unless rehardened.

(4) **Slocombe Drill and Countersink** combined. The angle of the countersink is the average angle used for the centres of lathes. This is used largely for the pieces of work that are to be turned in the lathe, as it drills and countersinks the holes for the centres at one operation.

(5) **Lathe Tools.**—Nos. (5-13) make a useful set for use in the slide rest and they are usually made of carbon tool steel, and in different size material according to requirements. No. 5 is known as a **Diamond-pointed Roughing-down** tool or a hook tool.

Description of Fig. 22 (*continued*).

(6) **Round-nosed Roughing-down Tool.**—If used on wrought iron or mild steel it cuts better if the right-hand corner marked A is ground down a bit lower than the front left-hand corner, about $\frac{1}{16}$-$\frac{1}{8}$ in. lower. But it depends on the metal being cut.

(7) **Right-hand Side Tool.**—Used for squaring up or facing off shoulders, etc., on the right-hand side.

(8) **Left-hand Side Tool.**—Used for the same purpose as (7), only opposite hand.

(9) **Vee Threading Tool** for cutting exterior threads with the automatic slide rest in action.

(10) **Square Threading Tool** for cutting exterior square threads with the automatic slide rest in action. Could also be used for a cutting-off tool. It is also easier to forge the nose at one side of the tool, instead of the centre as drawn. Simply a matter of taste.

(11) **Inside Boring Tool** for roughing out. Used mostly for shallow holes or rings.

(12) **Inside Boring Tool** for finishing cuts.

(13) **Inside Vee Threading Tool** for use with the automatic slide rest in action. The same kind of tool only with a square end instead of a vee is used for cutting inside square threads.

(14, 15, 16, 17) Tools used for turning brass. They have no top rake, and have cutting angles of about 70° to 90°. (14) Is known as a **Ripper,** used for roughing down; (15) is a **Planisher,** used for smoothing or finishing; (16) is a **Round-nosed Planisher**; (17) is a **Right-hand Side Tool** or an offset tool, used for squaring up shoulders, ends, and inside work.

(18) **Lathe Tool Holder.**—Used for holding high-speed steel turning tools. As these small tools can be ground on an emery wheel, and the holder takes the strain of the cutting, steel of small section can be used, so saving cost of material and the trouble of forging.

(19) **Spring Planisher** for finishing off iron and steel. If it springs too much a piece of hardwood is wedged in the hollow.

(20) **Three-jawed Chuck** fitted on to a face-plate of a lathe. The correct name is a Cushman three-jawed geared scroll chuck. It usually has two sets of jaws: the ones in the chuck are outside jaws.

(21) **Inside Jaws.**—For Cushman scroll chuck. These are all moved simultaneously by means of a key. Used for holding work that has to be turned.

(22) **An Independent Four-jawed Chuck,** with reversible jaws, slotted for bolts, and has not been fitted to a face-plate. Used for holding irregular shaped pieces of work, parts of which have to be turned. Holds work that (20) cannot hold.

(23) **An Archimedean Breast Drill-stock.**—Used by hand for light drilling.

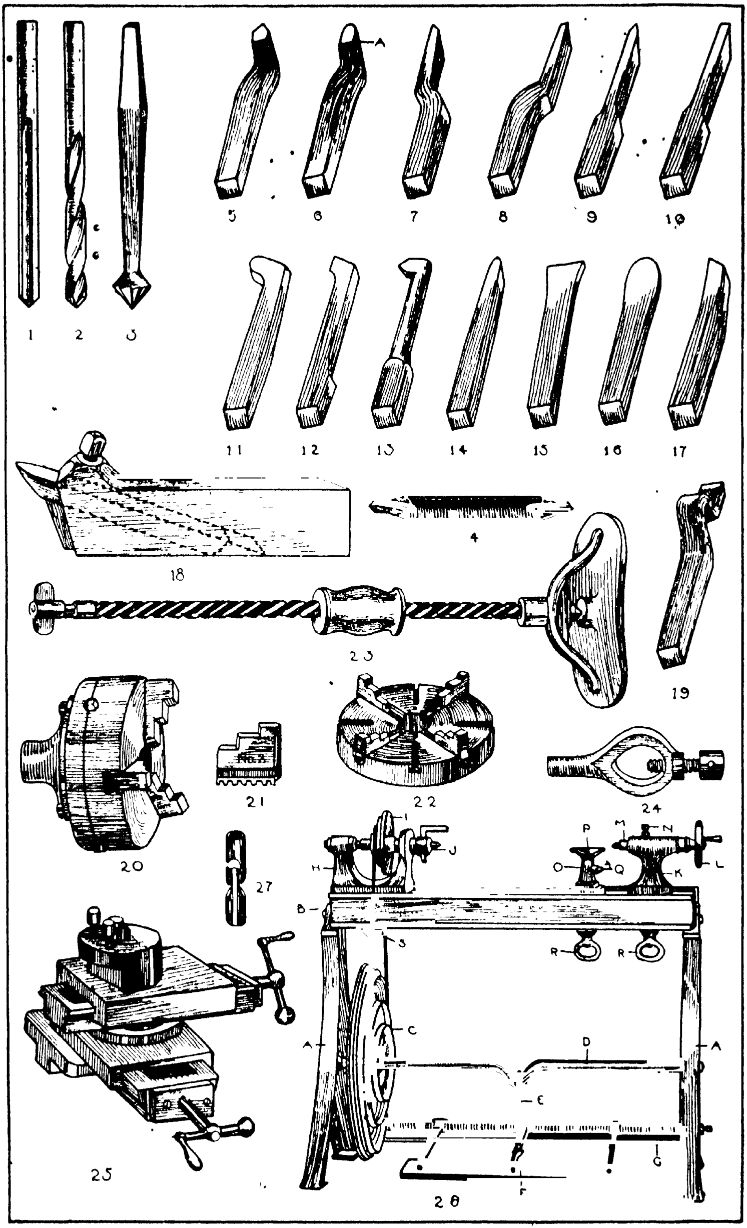


Fig. 22.—Metalworker's tools.

Description of Fig. 22 (continued).

(24) **A Lathe Carrier.**—Used for screwing down on to the end of a piece of work that is being turned between the centres of a lathe. The tail catches on the angle piece in the driving chuck J (26) or the dog in the driver plate. Made in many forms and in cast iron, malleable iron, and steel.

(25) **A Compound Slide Rest,** bolted to the bed of a lathe. Used for holding turning tools and moving them with precision The circular piece on top is the tool holder and it can be moved in a circle, and the two set screws hold the tool in position. The top slide moves parallel with the bed of the lathe, but it can also be moved in a circle by loosening two bolts which are underneath the top slide, about 30° each side of a line at right angles to the bed of the lathe. The bottom part of the slide rest is fixed, but the whole of the top portion can be moved at right angles to the bed of the lathe by means of the lower screw. The top slide, which turns on the bottom slide, allows for taper turning.

(26) **A Plain Foot-lathe.**—It is very simple, and rarely or never gets out of order. With a few accessories a wide range of work can be done with it. It is usually known by the length of the bed B and the height of its centre. That is the height from the face of the lathe bed to the point of the centre in the driving chuck J. The names of the parts are as follows :—

A. Standards or legs of cast iron.

B. Lathe bed Usually of cast iron with the top and top edges planed smooth and true.

C. Driving-wheel or fly-wheel of cast iron with vee grooves, for taking a round belt. A fairly heavy one is preferable.

D. Crankshaft. Made of wrought iron, with the ends case-hardened for the conical bearings. The fly-wheel is fixed on to the crankshaft by a key or with a set screw, the end of which goes a little way into the shaft.

E. Crank. Made of wrought iron. Sometimes called the pitman.

F. Treadle. It should be of hardwood and be as wide as convenient, as then it is more comfortable to use. The bolts after being tightened up should have the ends burred, or riveted up, if not, they soon work loose and drop out. The bar at the back to which the treadle supports are riveted, and which works between two centres, is called the treadle shaft.

G. Back stay or stretcher. Made of wrought iron Keeps the standards rigid and the correct distance apart.

H. Fast headstock. Made of cast iron, the tail end bored with a hole to take the tail screw, the front end bored to take a coned collar of hardened steel.

I. Driving pulley of cast iron. Fitted on to the steel mandrel. Kept in position by being a force fit. Has four grooves for the reception of the gut band.

J. Driving chuck. This screws on to the nose-piece of mandrel and is fitted with a catch bar which is kept in its place by means of a set screw. The centre is kept in position by being a taper fit.

Description of Fig. 22 (*continued*).

K. Tailstock or poppet head. Made of cast iron and drilled to receive the barrel M, which is screwed and is made to move backwards and forwards by means of the hand-wheel L. When necessary it is fixed by the set screw N.

L. Hand-wheel of cast iron. This is keyed on to a screw which works in the barrel M, so moving it backwards and forwards.

M. Sliding barrel. Made of wrought iron and screwed for the screw which is fixed to the hand-wheel L. Has a taper fitting at the forward end to take a centre, and has a keyway cut in its length into which a set screw is fitted, so preventing the barrel turning when the hand-wheel is turned.

N. Set screw of wrought iron or steel. Used for fixing the barrel.

O. Tool rest. Made of cast iron. Moves on a base plate, which is fitted to the bed of the lathe. Can be placed in any position.

P. Tee rest. Usually of cast iron, which in consequence generally gets broken. Should be of malleable cast iron or wrought iron. If holes are drilled in the top they add to its convenience.

Q. Set screw of wrought iron or steel. Fixes Tee rest in the correct position.

R. Hand nuts. Made of cast iron. Made like this so that they can be tightened without the use of a lever or spanner. They run up against the cast plates which fit the underneath part of lathe bed; these have a hole in them, through which the bolt passes.

S. Nut and cast plate for tightening up fast headstock.

(27) **Hook and Eye.**—Made of tool steel hardened and tempered to a purple colour and are screwed inside. They are used for connecting the gut belts used on light machinery and foot-lathes. The gut belt is tapered at the end and the hook or eye screwed on until the end of gut comes through; this end is then burnt down level with a red-hot piece of iron. Gut belts can be tightened by twisting them up, or loosened by untwisting them.

THE METALWORKING SHOP.

When setting out a metalworking shop for the purpose of giving instruction, the main idea should not be how much work can be turned out in a given time, or how much labour-saving machinery can we put into a given space, but rather, how can the maximum of instruction be given with the minimum of tools and appliances. By giving instruction without the aid of expensive equipment the resourcefulness of the student is developed as well as his adaptiveness. Moreover, a student, just because he is a student, is more likely to damage expensive tools. Often a student can repair a simple tool that he may have broken, and this in itself is a good training. With the shop planned and equipped with the plant and tools illustrated in Fig. 23, it is possible to do all the work indicated on these pages. All the tools and appliances shown have been proved to be the best and the most necessary for the teaching of metalwork on broad lines. But of course many can be done without, or many more can be added as occasion

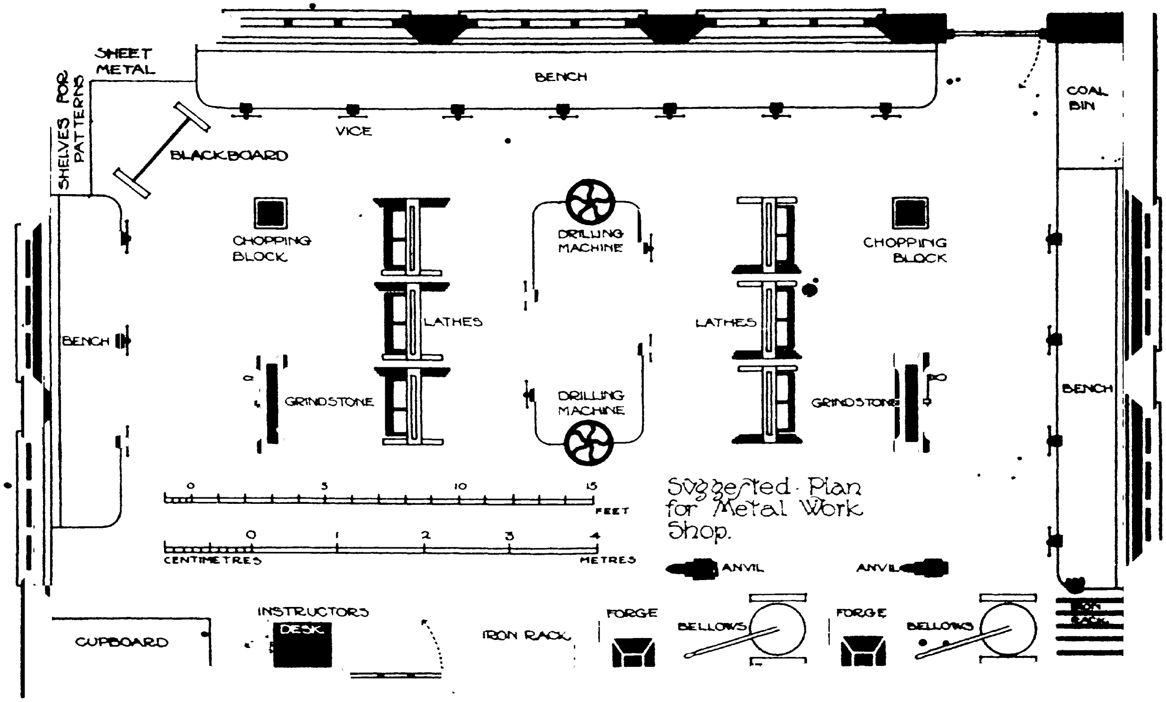


FIG. 23 —Suggested plan for a metalworking workshop

demands. The plan of a shop on page 219 is offered as a suggestion, and could if necessary be modified to suit conditions; but it is based on one in actual use, and is very convenient. An additional advantage would be a storeroom for the safe keeping of metals, etc., and a room suitable for the pickling, washing, and dipping of metals, with a small room for lacquering. The necessary working drawings to be used in connexion with the work could be done in the shop itself, as the patterns, tools, etc., necessary for reference are all handy.

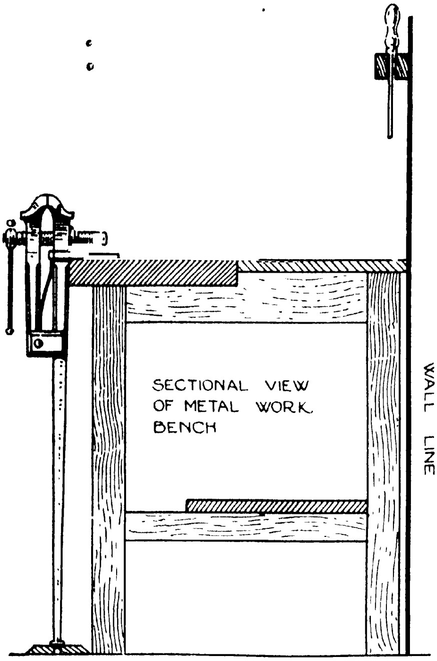
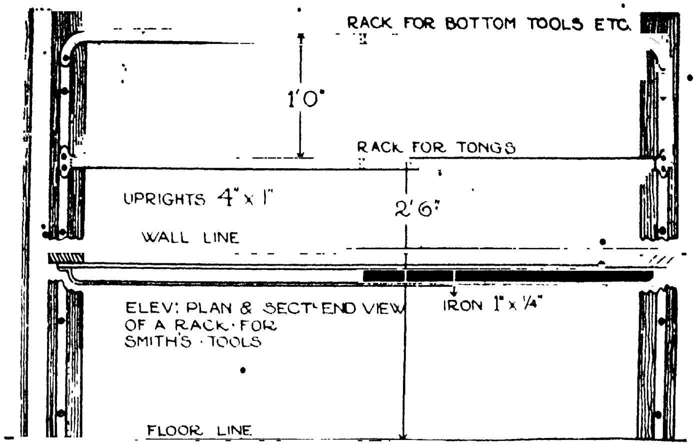


Fig. 24.

With reference to the ventilating, lighting, and heating:—

Plenty of windows with casements and fanlights above so that artificial light is not used more than is necessary, are suggested. In bad weather the fanlights can be opened when the casements cannot. For artificial lighting the use of individual lights to each vice and lathe, consisting of a single counterweight pendant, with switch lamp holder and lamp, are best. These are economical, as only the light actually wanted need be used.

For heating the shop in winter low-pressure steam seems very satisfactory and comfortable. In Fig. 24 will be seen the section of a bench with a rack for files above. The bench should be 2 ft. 9 in. high and 2 ft. 8 in. broad; the front board should be of beech 1 ft. 3 in. wide and not less than 2 in. thick. The bottom of the file rack should be 1 ft. 3 in. from the bench. Leg vices are very suitable for general use, as they are more solid to work on than parallel vices. Various sizes should be obtained, say from 3½ to 4½ in. jaw width. The jaws vary by ¼ in. The large vices should be fixed in close proximity to the forges. The rack for smith's tools illustrated on page 221 is most convenient if fixed to the wall by the side of the forges, as then the tools are close by and handy for working. In Fig. 26 is shown a strong wood stand for holding a cast-iron block which is used for chopping out work with hammer and chisel, as illustrated on page 62. The block measures 12 x 12 x 2½ in. A fillet of wood is screwed down all the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1'0"
RACK FOR TONGS
UPRIGHTS 4" x 1"
2'6"
WALL LINE
ELEV: PLAN & SECT' END VIEW OF A RACK FOR SMITH'S TOOLS
IRON 1" x 1/4"
FLOOR LINE

FIG. 25.—Rack for smith's tools

way round to prevent the iron block jumping off. Six of these blocks should be provided, two for the stands and four for bench use. The shop is designed for use without power; if power was installed the arrangement of the lathes, grindstone, and drilling machines would have to be modified. It is also arranged for eighteen boys and one instructor, but with the aid of another instructor and a little arrangement of the work ten more boys could be accommodated by using the six lathes and two forges, two boys to each forge, so making accommodation for twenty-eight.

If the shop was required for the use of advanced students, some additional machinery would be required, such as a planing machine, screw-cutting lathes, etc., and then power would be a necessity, and for the convenience of working it would be best to have all the machines in a separate shop.

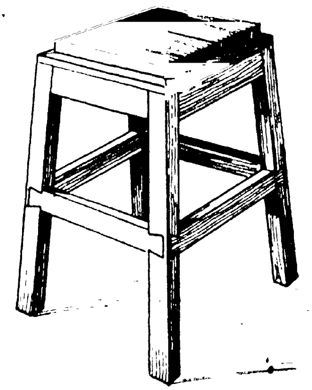

FIG. 26.—A chopping block on wood stand.

CHAPTER XVII

THEORY OF CUTTING ACTIONS OF TOOLS

THERE are many methods of cutting metals and necessarily many cutting tools, and a general knowledge of the main principles of the methods is of importance to any one who has to manipulate metals.

Only the elementary cutting tools which can be sharpened without expensive equipment will be dealt with here.

The most efficient cutting angle depends not only on the material of the tool itself but also on the material and condition of the metal to be cut.

To minimize the heat generated by the action of cutting, oil or some other lubricant must be used.

Cutting operations may be classified as follows: Chiselling, sawing, filing, shearing, punching, drilling, turning (including cutting with a diamond), screwing, milling, fusing.

Some of these processes are performed when the metal is cold, some must be done when the metal is hot, whilst for others the metal may be either hot or cold.

The action of a metal cutting tool is generally considered a shearing action. Shearing takes place when sufficient force is applied to tear away the metal from the main body so that the action may be taken as follows:—

Cutting with a metal cutting tool consists of pressing, tearing, and shearing the metal away with the one side or face only of the tool under pressure, as the opposite side is generally clear of the work, as in the action of a turning tool. This is illustrated in Fig. 1, No. 1. With a pair of shears both sides or faces of the tool are under pressure; this is shown in Fig. 1, No. 2.

In many instances a moving force is applied to the cutting edge of the tool and the substance is severed particle by particle. The tenacity of the material opposes the entry of the tool, but the first motion given to the tool, which severs a portion or a shaving which, directly it is away from the main body, is curled up, at the same time still presses down on the slope of the tool so keeping it up to the work. When the tool is too keen, as may be the case with a badly ground turning tool or twist drill, the cutting edge gets drawn into the metal by the same action and the point or edge gets sheared off.

In the use of a "hot sett" or "chisel" the action is rather that of wedging than that of shearing.

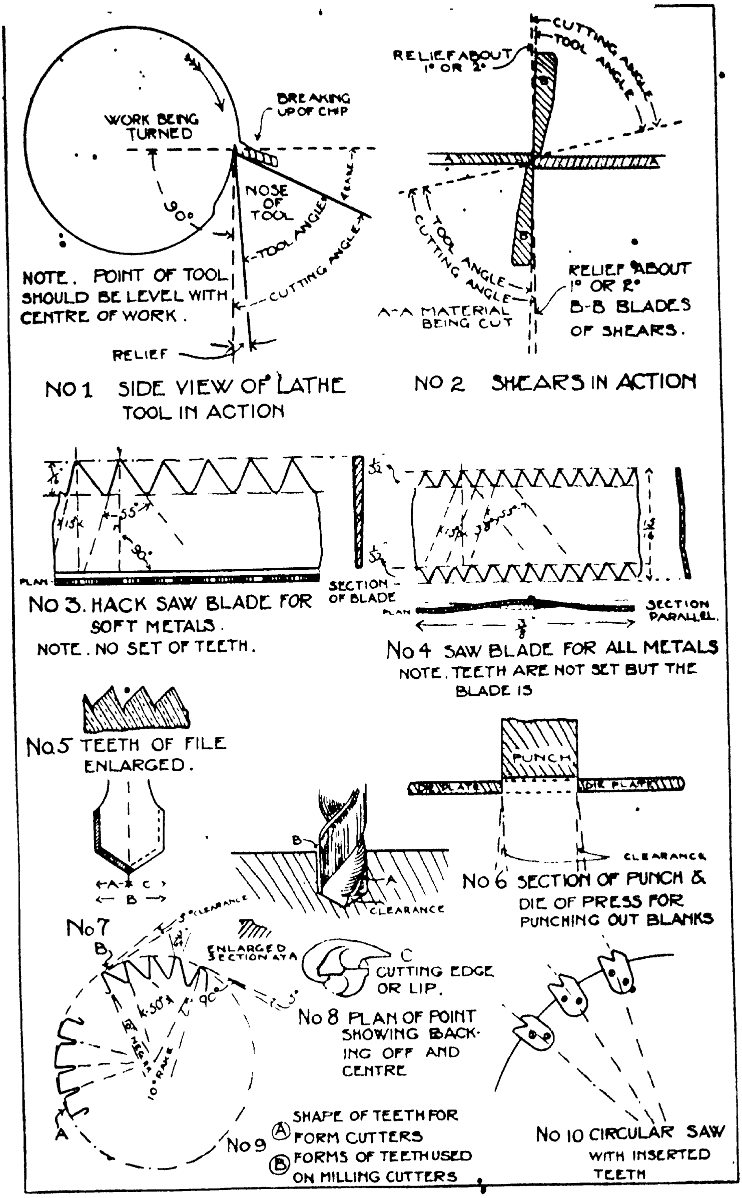
WORK BEING TURNED
BREAKING UP OF CHIP
90°
NOSE OF TOOL
RAKE
TOOL ANGLE
CUTTING ANGLE
NOTE. POINT OF TOOL SHOULD BE LEVEL WITH CENTRE OF WORK.
RELIEF
NO 1 SIDE VIEW OF LATHE TOOL IN ACTION
CUTTING TOOL ANGLE
RELIEF ABOUT 1° OR 2°
A
B
TOOL CUTTING ANGLE
A-A MATERIAL BEING CUT
RELIEF ABOUT 1° OR 2°
B-B BLADES OF SHEARS.
NO 2 SHEARS IN ACTION
1/15
55°
90°
PLAN
SECTION OF BLADE
No 3. HACK SAW BLADE FOR SOFT METALS.
NOTE. NO SET OF TEETH.
PLAN
SECTION PARALLEL.
No 4 SAW BLADE FOR ALL METALS
NOTE. TEETH ARE NOT SET BUT THE BLADE IS
No 5 TEETH OF FILE ENLARGED.
A
C
B
No 7
CLEARANCE
B
A
CLEARANCE
PUNCH
DIE PLATE
DIE PLATE
CLEARANCE
No 6 SECTION OF PUNCH & DIE OF PRESS FOR PUNCHING OUT BLANKS
ENLARGED SECTION AT A
C
CUTTING EDGE OR LIP.
No 8 PLAN OF POINT SHOWING BACKING OFF AND CENTRE
50°
90°
10° RAKE
A
No 9
Ⓐ SHAPE OF TEETH FOR FORM CUTTERS
Ⓑ FORMS OF TEETH USED ON MILLING CUTTERS
No 10 CIRCULAR SAW WITH INSERTED TEETH

FIG. 1.—Examples of cutting tools, their actions and cutting angles.

Chisels.—Chipping, the removal of metal by means of a chisel and hammer, is becoming obsolete, for machinery does the work better and quicker, and in large works pneumatic tools often take the place of the chisel and hammer. In small shops, however, the chisel is still a very necessary tool, and the one illustrated in Ch. VI, f. 1, is very useful for general purposes; but when used for chipping only, the cutting edge instead of being straight across (as drawn) should be slightly curved, so that in actual use the corners will not break off or be drawn into the metal. For cutting soft metals such as brass, copper, etc., a more acute cutting angle could be used with advantage, say 50° instead of 60°, and it could be left a little harder by cooling out when temper colour is a light brown.

Saws.—The "hack saw" illustrated in Fig. 1, No. 3, which should be held as illustrated in Ch. XVI, f. 17, is used only on soft metals, and the angle to which the teeth should be filed is shown in Fig. 1, No. 3, but the best method is to sharpen the teeth on an automatic grinding machine which not only grinds the teeth to the correct slope but spaces them as well.

Metalworkers do not always rely on "set" of teeth to keep a clear kerf and so prevent the saw from binding, as the saws with thin backs keep their edge better, answer the same purpose, and are more common.

A most efficient saw for cold iron or steel as well as for other metals is shown on the same page (Fig. 1, No. 4). This, a Bradenberg patent, has a very ong life; the peculiar "set" should be noticed. Some saws are made with teeth that are "set" and hardened and the backs left soft.

Metals are now sawn either hot or cold, a circular saw running partly immersed in a bath of cold water for hot metal, in a bath of oil for cold metal. Names of the parts of a saw are as follows: "Space" is the distance from tooth to tooth measured at the points; "gullet" or "throat" is the depth of the tooth from point to the root; "gauge" is the thickness of the saw generally measured by the wire gauge; "set" the amount of clearance given to the saw teeth in either direction to prevent the saw binding and to clear away the chips.

Filing.—A file is one of the principal tools of a metalworker and the most difficult to master. It consists of a steel blade or body of very variable form and size with a "tang" for fixing into a handle. Teeth of suitable form and size are cut on the blade, and the latter is hardened and tempered. Files are classified and described according to the form, use, and nature of their teeth. Most of the terms used to describe the form require no explanation, e.g. parallel, half round, round (a taper round is called a rat tail), triangular; a knife file has a section like the section of a knife blade; a warding file is a very thin flat file used for filing the wards in keys. Pillar and cotter files are narrow files of rectangular section. A riffler is a bent file used for filing concave surfaces. Feather-edge files have a rhombic section with two very acute and two very obtuse angles. The teeth or cut of a file are spoken of as rough, middle, bastard, second cut, smooth, and dead smooth, according to the number of teeth per inch, which ranges from about 14 to 100 or more. The teeth of an ordinary file form two sets crossing each other at an angle; this arrangement constitutes the double or cross cut. A file with a single set of teeth is termed a float. A safe-edged file is one which has one size or edge without teeth. Rasps may be grouped with files; though their use is chiefly confined to the woodworking trades, their form and process of manufacture are similar to those of files; but the teeth consist of "burrs" thrown up with a diamond-pointed chisel instead of the straight-edged chisel which is used in making the teeth of a file.

The action of filing is similar to that of sawing, consequently it is a scraping action, and if the teeth of the saws in Fig. 1, Nos. 3 and 4, are compared with the enlarged section of the file tooth, Fig. 1, No. 5, on the same page, the similarity is at once apparent It should be noticed that in all files the front part of the tooth slopes backwards or has what is termed "negative rake". The width of the tooth at the bottom and the height of it have a great deal to do with the life and efficiency of a file, for if the tooth is high and narrow it is liable to chip or wear away more rapidly that if the tooth was of medium height and had a wide base, which gives solidity and length of life owing to having plenty of support under the cutting edge. The angle of the cut in relation to the axis of the file is also important, as by means of this we get a slicing cut which causes the metal to come away in curled chips and with comparative ease

All files have a small amount of curvature in their length. If a flat file is examined it will be seen to be thickest in the middle, and this allows a nearly flat surface to be obtained by filing, as any high part of the surface can be filed down in that particular place by slightly raising the handle of the file and pressing with the left hand on the front portion of the blade.

A scraper is usually a triangular file ground at the end on all the faces so giving three keen edges which are finished up on the oil stone; of course there are many other forms, but this is very effective This acts in the same way as a file, only it is like one tooth being used instead of a number, and it has the advantage of being able to be held so that it will cut quickly or slowly according to the angle of the face presented to the work. Another most important point is the height the work should be so as to obtain the best results, and as the work is usually held in a vice this governs the work. The right height for the tops of the jaws of a vice is, when the worker is standing upright with his elbow close to his side and his hand touching his shoulder the tops of the jaws should just touch the point of his elbow.

The most suitable files for use in a general way are 4 in., 6 in., 8 in., 10 in., 12 in.; half round bastards and smooths, safe edge bastards and smooths. A few rat-tail files, and some safe-edge squares might be added as the necessity arose. Files used for iron and steel should be kept separate from those used on soft metals; and when new files that have been used on soft metals will not cut, pass them on to be used on iron and steel which they will cut admirably. New files used on iron and steel get the teeth chipped, and wear out rapidly.

When a file gets clogged it should be brushed with the file cleaner (Ch. XVI, f. 16); if some pieces of metal get jammed in between the teeth of the file and cause scratches on the work being filed, they can be removed by pushing them out with the corner of a flat piece of brass or iron; these small pieces of metal are called "pins". To avoid these when filing iron or steel chalk the file or put a spot or two of oil on it. When filing aluminium use paraffin or turpentine. The proper method of standing and holding a file is shown in Fig. 2.

FIG. 2.—Position when filing.

Shearing and Punching.—Shearing is explained in the early part of this chapter, and the action is the same in punching, as both edges cut in each case, and both act on the two sides of the metal. This can be seen by referring to Fig. 1, No. 6. It will be noticed, however, that the punch itself has parallel sides while the die has a very slight clearance to prevent the punch binding. The use of the punch in smiths' shops, however, is quite different, as when a piece of iron is brought to a bright red heat and then a hole is punched in it by driving a punch which tapers a little outwardly towards the top, through the metal with the aid of a hammer, the hot metal is first of all pressed from underneath the face of the punch and then the punch is usually driven half-way through from each side so forcing the metal outwardly and enlarging the hole. This action makes a swelling on the bar where the hole has been punched, so retaining practically all of the material and hardly weakening the bar to any extent. In the action of punching as illustrated in Fig. 1, No. 6, the bar is weakened according to the amount of material removed, but it is quicker and a machine does the work.

Drilling and Turning.—Drilling, turning, and boring are three different operations. In drilling the work is stationary and the drill revolves, in turning the work revolves, and in boring the work is fixed to the saddle of a lathe which travels in a given direction, while the boring tool is fixed in a boring bar which is placed between the centres of a lathe and revolves.

This is the general practice, but of course there are many variations; the action of boring is similar to drilling, though one could not drill a hole with a boring tool. Drilling differs in principle from almost every other operation in metal cutting, as it cannot be guided in any given direction and is supported by the bearing of the cutting edges of the drill against the material. The ordinary flat or diamond-pointed drill (Ch. VI, f. 6) is a most useful tool, because it can be easily made and tempered, and will withstand very rough usage, but it does not cut in the true sense but scrapes, and requires great pressure to force it into the metal, and cuts very slowly.

If the lip A (Fig. 1, No. 6) is longer than lip C the diameter of the hole will be twice the radius of A, as this drill is guided solely by its point, and the hole so drilled will bear no relation to the diameter B. Another disadvantage of this form of drill is that if the metal is spongy or has blow holes in it where a hole is being drilled it will run into the softest part, or into the space away from the harder metal, so giving an uneven or slanting hole.

For rapid and good work twist drills, brought to perfection by Mr. Morse of America, are universally adopted. This drill is illustrated in Ch. XVI, f. 22. To obtain the best results with this drill it should be ground on an emery wheel with an automatic twist drill-grinding attachment, for unless the lips are equal a larger hole is made than the diameter of the drill, as illustrated at B in Fig 1, No. 7. If the angles of both the lips (which should be 120°, that is 60° each side of the centre of the drill) are not the same, one lip does all the work, consequently it soon dulls and requires regrinding. Another important point is that if the cutting edge or lip C of the drill is not the highest point or has not the proper amount of "clearance," it will refuse to cut, or if it is too high it gets drawn into the metal and is then broken off.

When the point of the drill protrudes through the stock being drilled, but is not quite through, extra care must be taken or the drill will catch in the fash of the hole and get broken The spiral grooves of the twist drill provide the "rake," and this causes the chips to curl out of the way instead of being pulverized as is the case with the flat drills and less power is required. Some twist drills have oil holes through the centre so that the cutting edges can be lubricated. The sense of feeling is or can be utilized more in drilling holes than in any other operation, and so the operator can tell whether the drill is doing the work as it should, so avoiding accidents.

Turning.—This is partially explained in the early portion of this book (p. 79) and also by the diagram No. 1 on p. 223, but further, the most suitable angles for the various metals are approximately as follows (though the best angle is determined by trial and the shape of the tool being varied according to the hardness of the material being cut):—

	For Wrought Iron and Mild Steel	For Cast Iron	For Brass and Cast Steel
Cutting angle	60° to 70°	70° to 80°	80° to 90°
Relief	4° or 5°	3°	3° to 5°
Tool angle	55° to 65°	63° to 80°	70° to 87°
Rake	20° to 30°	5° to 20°	0° to 12°

n actual practice the most efficient angle is that which cuts the sweetest and lasts the longest, but the three factors which tend towards or cause the destruction of a turning tool are :—

1. Actual wear due to use.

2. Presence in the material being cut of impurities which are harder than the tool itself.

3. The heat generated which may be sufficient to soften the cutting edge. This last factor does not operate to the same extent where high-speed steel is being used.

In round-nosed roughing down tools such as shown in Ch. XVI, f. 22, No. 6, there should be " side rake " as well as " top rake ". Side rake is not shown in No. 6, but it could be obtained by lowering the corner marked A.

Castings of iron should have the scale removed with an old file, or by pickle, or by chipping, before they are turned, as the scale ruins the turning tools owing to its hardness.

The turning tools for brass are very simple, and their cutting angles must be very obtuse or even square as, if made acute they tear the metal or "draw in," and if the job is not held firmly and without any shake it is liable to be full of ripples or striæ. A quicker speed should be used than that in turning iron. Turning tools consisting of black diamonds brazed into suitable shanks are being used in America, and it is claimed by the users that they are as superior to high-speed steel tools as the latter are to carbon steel tools, and in the long run they are cheaper.

Screwing is done in many ways, and when a thread is cut on a piece of work in a lathe, the action is the same as turning, only the movement of the threading tool is sometimes different. Threads are cut by special thread milling machines, by dies which are operated by power, or by hand, by taps. Taps are illustrated in Fig. 18, p. 206. Dies are illustrated in Fig. 18 on the same page. The dies have to be held in various ways, one of which is in the stocks illustrated on the same page.

For cutting screws of different numbers of threads in a lathe the lathe has to be specially designed, and it is usually known as a screw-cutting lathe. The action of a tap cutting a thread is the same as that of a turning tool, as the cutting edge of the thread on the tap has relief made by the " backing off " and rake caused by the shape of the hollows which are milled out of the tap. It is found in practice that when the hole is drilled slightly larger than the theoretical core diameter and then tapped, nearly as good a thread is obtained as would have been if the hole had been the correct size, and this relieves the tap of a portion of the strain. During the cutting of the thread, and owing to the tap forcing its way into the metal, not only is the material removed but it is also squeezed between the threads, so decreasing the diameter of the hole. This illustrates the " flowing " power of metals. This action does not take place in cast iron. In comb or hand chasers, which are illustrated in Ch. XVI, f. 18, there is relief but no rake, and as they are usually used on soft metals it is not necessary.

Milling is shaping or cutting metal by means of a revolving cutter, and is usually performed in "milling machines," which are made in many forms suitable for various requirements. Cutters are made of almost infinite variety and with varying number of teeth. In some machines the work revolves as well as the cutter. Some work can be done very much quicker on a milling machine than it could be done on a lathe, as milling machines can be run at considerably higher speeds than other tools, as each tooth of the cutter is in contact with the work for only a small portion of the revolution and has a chance of being cooled by the lubricant used. The majority of milling cutters have the front faces of the teeth radial or without any rake, as shown on p. 223, Fig. 1, No. 9, and each tooth should act as a turning tool. Cutters for mild steel cut better with a small amount of rake, but for brass negative rake is necessary. "Form" cutters are those which produce a formed surface and are "backed off" so that they retain their original shape after grinding, which is done on the face of the tooth marked A, Fig. 1, No. 9. Other cutters are sharpened by grinding at B as shown in the same diagram. Milling cutters are also made with inserted teeth, that is, the body is of soft iron and the teeth which are made of special steel are fitted into grooves and screwed into position. This makes a very durable tool, for when a tooth gets damaged it can be easily replaced.

Fusing.—Cutting Metals with Oxidizing Flame.

The oxy-hydrogen and oxy-acetylene flames are specially adapted to cutting metals. When iron or steel is heated to a high temperature it has a great affinity for oxygen and readily combines with it to form different oxides. This causes the metal to be disintegrated and to burn with great rapidity. The metal-cutting blow-pipe operates on this principle. Ordinarily two jets or flames are used. First there is an ordinary welding flame for heating the metal and this is followed by a jet of pure oxygen, which oxidises or burns the metal. The jet of oxygen is made sufficiently strong to blow away the iron oxide in front of it, with the result that a clear narrow cut is effected through the metal at a speed of travel similar to hot sawing. Metal can be cut up to six inches in thickness with the oxy-acetylene, and up to twenty inches with the oxy-hydrogen flame.

Liquid air oxygen has been used in cutting up armour plate fourteen inches thick at a speed of 4½ to 5 minutes per foot run.

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PRINTED IN GREAT BRITAIN BY THE UNIVERSITY PRESS, ABERDEEN